Vol. LXXX OCTOBER, 1924 No. 4

ANNALS of SURGERY

A Monthly Review of Surgical Science and Practice

Edited by
LEWIS STEPHEN PILCHER, M.D., LL.D.
of New York
With the Association of
JAMES TAFT PILCHER, B.A., M.D.
and the Collaboration of
W. SAMPSON HANDLEY, M.S., M.D., F.R.C.S.
of London

J. B. LIPPINCOTT COMPANY, PUBLISHERS
MONTREAL PHILADELPHIA LONDON

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ANNALS of SURGERY

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THE EFFECT OF PRESSURE ON ARTICULAR SURFACES IN PYOGENIC AND TUBERCULOUS ARTHRITIDES AND ITS BEARING ON TREATMENT*

BY DALLAS B. PHEMISTER, M.D.
OF CHICAGO, ILL.

IT WAS recognized that pressure played a rôle in the destruction of articular surfaces in arthritis long before the bacterial nature of infection was known. Since the time that pyogenic and tuberculous arthritides were differentiated bacteriologically, the differences in the effects of contact and pressure on the articular surfaces in the two conditions have not been fully elaborated. In fact, it is too generally considered that they are much the same in the two conditions, that the effects are destructive, and that in both the articular surfaces are destroyed first and most extensively at the points of contact and pressure of opposing articular surfaces. Examination of a series of specimens showing each disease in its various stages demonstrates that this is not the case. The changes as influenced by contact and pressure are more accurately described for pyogenic than for tuberculous arthritis. Koenig's [1] work on tuberculous arthritis is the most extensive and exact, but inaccuracies may be found in it pertaining to the persistence of cartilage longer at certain points than at others and to bony invasion and necrosis. Also, knowledge as to proteolytic activities in pyogenic and tuberculous infections has not been utilized in explanation of the changes seen in articular cartilages in pyogenic and tuberculous joints.

In studying the effects of contact and pressure, a distinction should be made between those produced on the articular cartilage and those produced on the underlying bone. In acute pyogenic arthritis it is found that when there is an effect from contact and pressure, it is to help to destroy articular cartilage in the regions of contact of opposing articular surfaces. On the other hand, in tuberculous arthritis the effect, except in the later stages, is protective, and articular cartilage is usually preserved longest at the points of contact and pressure, while the first evidences of destruction are found over the free surfaces. The differences are present because the agents which attack and destroy articular cartilage are very different in the two processes. These observations have been made mainly on adults and on the knee-joint, where, because of large areas of both free and opposed articular surfaces, conditions are favorable for contrasting the effects of pressure and lack of pressure. They hold in varying degrees for other joints and for children. In both

* Read before the American Surgical Association, April 18, 1924.

pyogenic and tuberculous infections the articular cartilage is involved secondarily, the primary infection being either in the synovia or in the bone.

Pyogenic Arthritis. Effects of Pressure on Cartilage.—In pyogenic arthritis the articular cartilage may not become involved if the infection is mild, but if the infection is severe, cartilage will be killed, and it is generally killed first and most extensively at the points of contact and pressure of opposing articular surfaces. This is undoubtedly related to the unfavorable conditions for nutrition produced by pressure. The amount of necrosis on surfaces that are not pressed upon varies. In some cases it is slight, while in others the entire cartilage may be killed. Whatever happens on one side of the joint usually happens on the other. If cartilage is killed in the apposed regions on one side, it is usually killed to the same extent on the other side. Dead cartilage in pyogenic arthritis is usually destroyed in a comparatively short time. It is broken down partly by the absorptive action of granulation tissue, partly by erosion of opposing articular surfaces, and partly by the digestive action of proteolytic ferments in the exudate of the joint. These ferments are derived very largely from the polymorphonuclear leucocytes, to a slight extent from broken down bacteria. Where cartilage is killed in its entire thickness, granulations from beneath its attached surface and rapidly detach it by absorption of both cartilage and bony cortex at their junction. Where only a superficial layer of cartilage has been killed in unopposed regions, it is removed mainly by digestion, but granulations may also grow from the margins over the unopposed surfaces and absorb the dead layer.

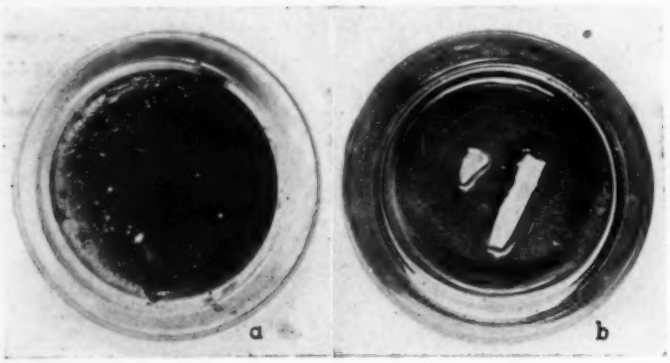

FIG. 1.—Equal amounts of articular cartilage in staphylococcus pus (a) and in tuberculous pus (b) after incubation at 55 degrees C. for ten hours; cartilage digested in (a) and undigested in (b).

A series of experiments has been performed to test the rapidity with which articular cartilage is digested by a pyogenic exudate *in vitro*. When pieces of articular cartilage are immersed in pus produced by any of the pyogenic microörganisms and the mixture incubated at a temperature of 55 degrees C., so that proteolytic action is augmented, the cartilage is digested in from three to twenty-four hours, depending on the concentration of the pus. Figure 1 shows two watch glasses, each of which at the beginning of the experiment contained two pieces of fresh articular cartilage and underlying bony cortex of the size shown in (b). Staphylococcus pus was added to (a) and pus from a tuberculous cold abscess to (b). After incubation for ten hours, the articular cartilage in (a) was completely digested and particles of bone sand were the only solid materials remaining. The pus was more liquid than at the beginning of the experiment, because of the breaking down of its proteids and of the leucocytes themselves. At a temperature of 55 degrees C., bacterial action is suspended, so that the digestion was produced by existing ferments in the pus. That the ferments are derived very largely or wholly from the polymorpho-

nuclear leucocytes in the exudate is shown by the fact that relatively little or sometimes no cartilage is digested, when it is incubated in a suspension of pyogenic bacteria. Experiments have demonstrated that a variable amount of proteolytic ferment is formed by different organisms, as shown by their ability to break down tissues and to liquefy such media as gelatine and blood serum. According to Bittrolff,[2] it is small in amount with most pathogenic forms. Heavy suspensions in normal salt solution of some strains of staphylococcus aureus were found not to digest articular cartilage, while others digested it to a slight degree. In the experiment shown in Fig. 2, equal sized pieces of articular cartilage were placed in the tubes. Tube (1) contained normal salt solution, tube (2) a suspension of staphylococci in a concentration of 15 millions per cubic millimeter, and tube (3) a suspension of 40 millions per cubic millimeter. They were incubated at 55 degrees C. for six days and there was no reduction in size of the pieces of cartilage. Microscopic examination of sections showed cartilage well preserved in the piece incubated in salt solution and only very slight breaking down of cells and vacuolation of intercellular substance in the pieces incubated in the staphylococcus suspensions. The experiments of Bittrolff,[2] Cacace [3] and others have shown that proteins may be split by the action of bacterial ferments into albumoses, peptones and amino-acids.

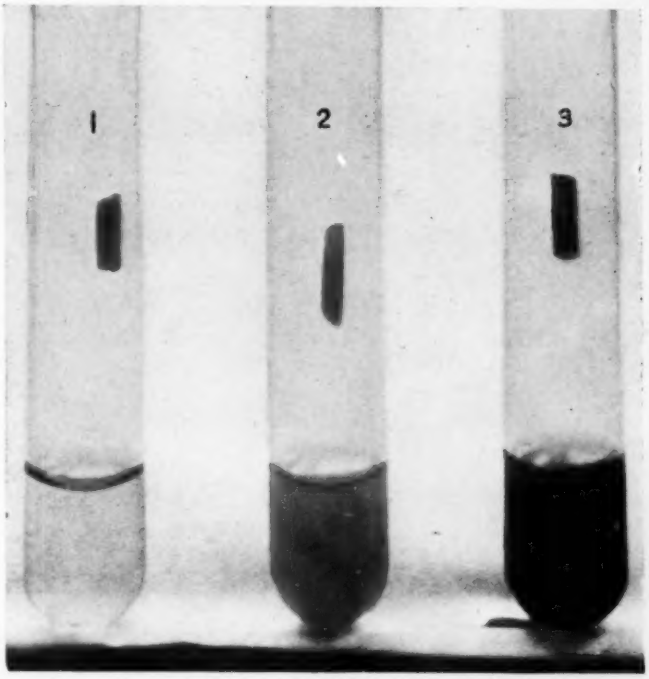

FIG. 2.—Equal sized pieces of articular cartilage incubated at 55 degrees C. for six days in normal salt solution (1) and staphylococcus suspensions (2) and (3). No change in (1) and only slight microscopic changes in (2) and (3), showing little digestion by the bacteria.

Effects of Pressure on the Bone.—In pyogenic arthritis the changes in the bone bordering on articular surfaces vary according to the point of primary infection. In primary arthritis with secondary involvement of cartilage, the articular cortex of bone is nearly always destroyed in those regions where the entire thickness of articular cartilage is broken down. Consequently it is destroyed oftenest and most extensively at the points of pressure. An inflammatory reaction is seen in the adjacent layer of spongy bone of these regions, but deep invasion producing osteomyelitis and sequestration, even at the points of pressure, is rare. In infected penetrating wounds of joints with associated joint fracture and osteomyelitis, death of detached bony fragments is common. When the primary infection is an osteomyelitis which spreads into the epiphysis and the joint, necrosis and sequestration of bone bordering on the articular surface is not uncommon, and even here, as in the head of the femur, it may be greatest in the weight-bearing region. When bone and overlying articular

cartilage are both killed, the cartilage rapidly disappears by the digestive action of ferments, but the dead bone with its layer of articular cortex may persist and be separated as a sequestrum.

Figure 3 shows a photograph of the articular surfaces of the bones of the knee and ankle, which were involved in arthritis by direct extension from staphylococcus osteomyelitis of the entire shaft of the tibia in a twelve year-old boy. The infection in the knee was purulent and was drained on the fifty-fourth day, when the patient was admitted to the Presbyterian Hospital. That in the ankle was less severe and had subsided without drainage when the limb was amputated above the knee on the seventy-fifth day of the illness. Articular cartilage and cortex of bone were almost completely destroyed at the points of contact and pressure of os calcis (a) with the tibia (b), but were preserved about the sides of the joint on os calcis, tibia and fibula, where there was little or no pressure. At the knee, where the arthritis was severe, the destruction of articular surfaces was more marked. The infection had involved a part of the upper epiphysis of the tibia and had killed articular cartilage and underlying cortex of both tibial tuberosities (c). The cartilage had been destroyed by digestion, but portions of articular cortex were present as disc-like sequestra. The one on the internal tuberosity is shown *in situ* at (y) in Fig. 3. The femur (d) showed complete disappearance of articular cartilage and of underlying cortex on the condyles at the points of contact and pressure with the tibia and partial destruction of cartilage and cortex at the point of contact with the patella, which latter structure had also lost its cartilage, excepting remnants about the periphery. The cartilage was largely preserved on the remaining free surfaces anteriorly between the points of contact with patella and tuberosities, and posteriorly on the condyles, but its surface was mostly uneven from superficial destruction.

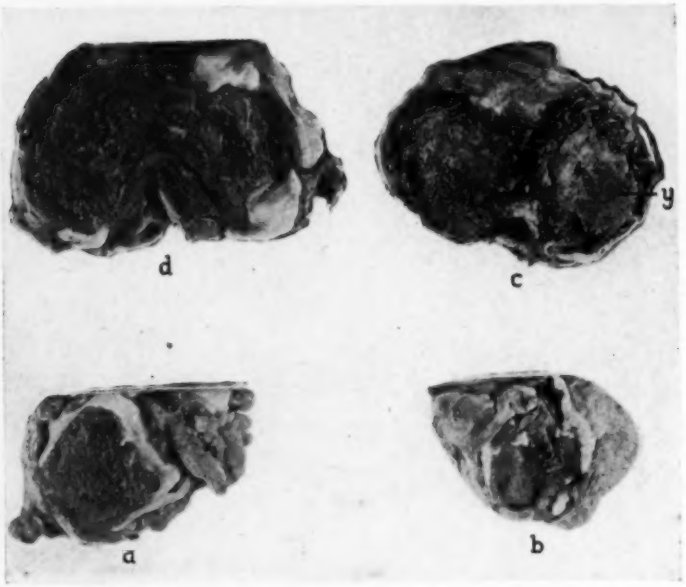

FIG. 3.—Joint surfaces in pyogenic infections of knee and ankle. Cartilage destroyed at pressure points and largely preserved where not compressed on astragalus (a), lower end of tibia (b) and femur (d). Cartilage all destroyed on upper end of tibia (c). Cortical sequestrum (y).

This case illustrates well the disappearance of cartilage and cortex where pressed upon by opposing articular surface, the survival of cartilage in the regions of the joint that are free from pressure, and the preservation of bony cortex and disappearance of cartilaginous covering on an articular sequestrum. A comparatively mild acute arthritis may involve articular cartilage at the points of greatest pressure, which will lead to bony ankylosis, unless measures are introduced to combat it.

EFFECT OF PRESSURE ON ARTICULAR SURFACES

Figure 4 shows a photograph of the articular surfaces of the right knee five months after the onset of a hæmatogenous arthritis secondary to erysipelas of the left thigh. There was an effusion at the onset and aspiration yielded a turbid serous fluid, from which a hæmolytic streptococcus was grown. The infection subsided spontaneously after six or seven weeks, leaving the joint with only a small range of motion. Extension was not applied to the limb, nor was the joint mobilized. The limb was amputated because of recurrence of an old staphylococcus osteomyelitis of the upper end of the femur with coxitis. Dissection showed destruction of articular cartilage and cortex at the points of contact of external condyle (a) and external tuberosity (b), which is the region of greatest pressure in the knee-joint, and a bony bridge was in process of formation here. The articular cartilage was preserved elsewhere on the tibia and femur and on the patella, but there was extensive fibrous ankylosis present in these regions. The extreme degree of destruction of cartilage and fibrous ankylosis resulting from the comparatively mild arthritis was no doubt related to the fact that the knee was neither mobilized nor extended during any part of the course of the infection.

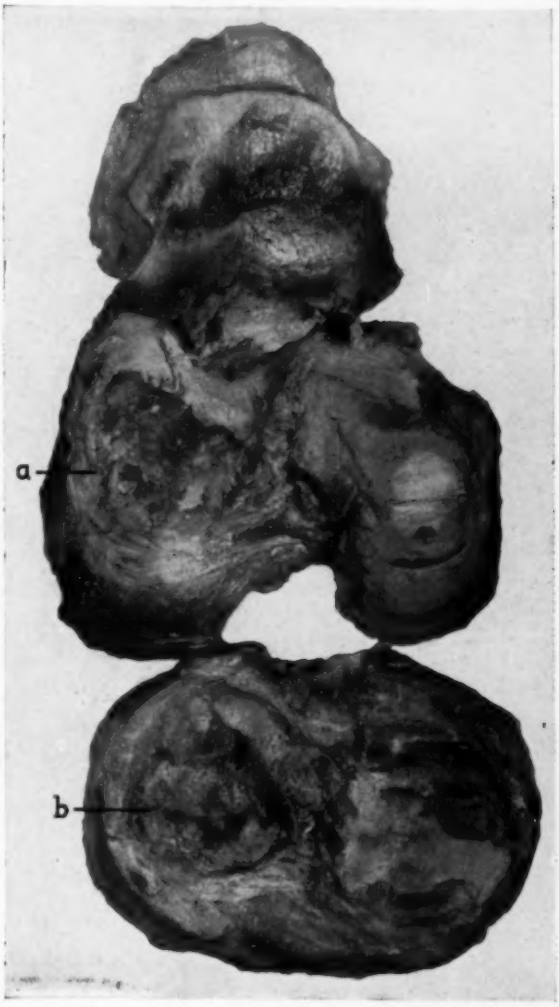

FIG. 4.—Ankylosis five months after mild undrained arthritis of knee. Cartilage destroyed only at points of pressure of external condyle (a) on external tuberosity (b). Fibrous ankylosis elsewhere.

In moderately severe pyogenic arthritis, it may rarely happen that articular cartilage and underlying cortex are destroyed at the points of pressure on one side of the joint and persist on the other. The presence of cartilage on one side lessens the liability to the development of ankylosis, and there may be healing with preservation of considerable motion. The area of destroyed articular surface is repaired by the outgrowth of granulation tissue from the underlying bone, and it may overgrow the surrounding cartilage, producing a ridge about the margins of the defect. These granulations change into fibrocartilage and may ossify in their deeper portions, producing osteophytes on the articular surface. Figure 5 shows the articular surfaces of a man's knee, resected one year after spontaneous healing of a mild seropurulent arthritis, resulting from extension of a staphylococcus osteomyelitis of the tibia. The articular surfaces had been destroyed at the points of contact on the condyles of the femur, but not on the tibia, where they were somewhat protected by the marginal support of the semilunar cartilages. The

damaged areas on the condyles had been repaired by a layer of fibrocartilage, the margins of which were raised and in places overhanging. A sagittal section through the lateral condyle showed that articular cartilage and cortex had been destroyed at the point of greatest pressure and that reparative tissue had grown over from the underlying bone, filling the defect and overlying the margins of surrounding cartilage. (Fig. 6.) The superficial portion of this tissue was fibrocartilage, while the deeper portions had ossified.

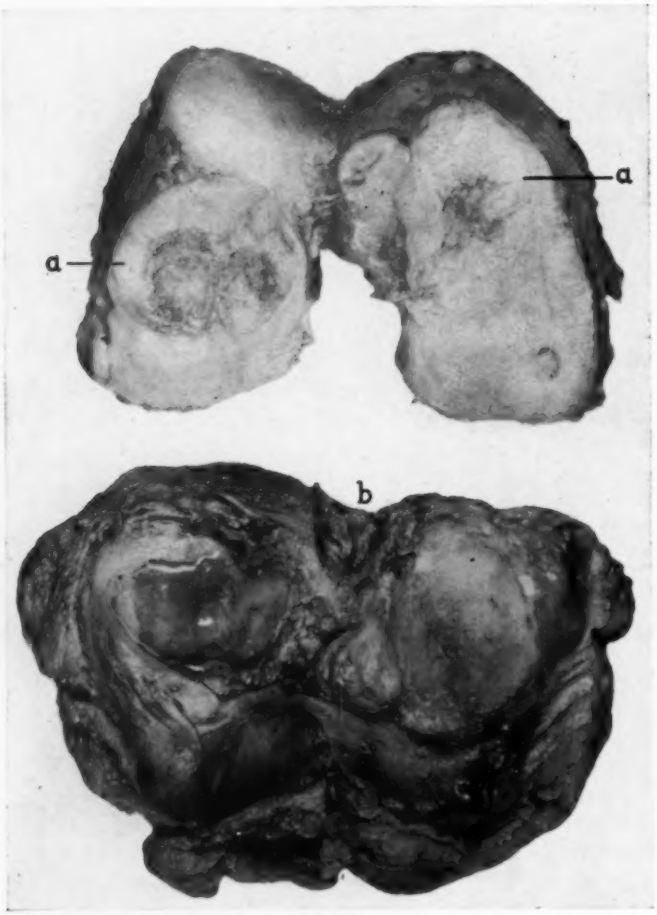

FIG. 5.—Healed undrained pyogenic arthritis of knee. Roughened healed areas where cartilage is destroyed at points of pressure on condyles of femur (a); cartilage on tibia (b) little changed.

The shadow cast in the röntgenogram by the new bone overlying the remaining articular cartilage gives the appearance of a bony disc interposed in the cartilage space of the joint between condyle and tuberosity (Fig. 7). If cartilage and cortex break down on both sides of the joint, it is extremely difficult to avoid the occurrence of bony ankylosis.

Tuberculous Arthritis. Effects of Pressure on Cartilage.—In tuberculous arthritis the point of primary infection is either in the bone or in the synovial lining, and the articular cartilage becomes involved secondarily. The inflammatory reaction is not sufficiently severe to kill articular cartilage *en masse* in the early stages of the disease, as is so often the case in pyogenic arthritis. Tuberculous synovitis usually runs for months and is well established before there is any sign of destruction of articular surfaces. The articular cartilage is then first killed and absorbed by the direct attack of tuberculous granulations, which grow onto it from the surrounding synovia. They attack it first along its free surfaces and about its margins, where they can readily get at it. The cartilage is protected from surface attack of tuberculous granulations in the regions of contact and pressure of opposing surfaces in the joint, and the

destruction may be very marked along the free surfaces and about the margins before there is any change in the cartilage of the contacted regions.

This is illustrated by Fig. 8, which shows the articular surfaces of the resected femur and tibia in tuberculosis of the knee of about fifteen months' standing in an eighteen year old boy. There was marked tuberculous synovitis and granulations had attacked the cartilage of the tibia about its margins, but the central portions of cartilage on either tuberosity were free from attack, as were the surfaces of the condyles of the femur with which they come in contact. The surfaces of contact of patella and femur were also free. Granulations covered the free cartilaginous surface of the femur between its points of contact with patella and tibia and on the posterior surface of the condyles, and had absorbed most of the thickness of cartilage. The layer of granulations is seen intact between patellar surface and internal condyle, but it has been removed, leaving a grooved and roughened surface, between the patellar and external condylar surfaces.

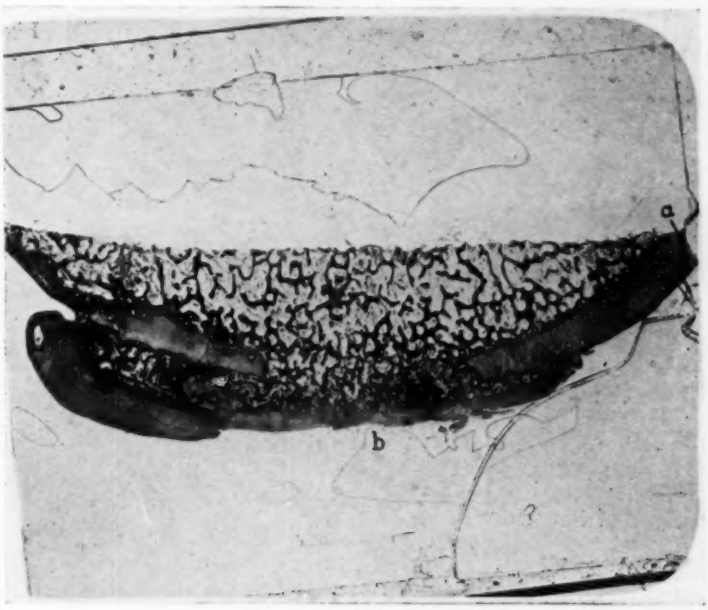

FIG. 6.—Section through external condyle shown in Fig. 5, showing layer of articular cartilage (a) destroyed at point of greatest pressure and overgrown by partly ossified reparative tissue (b) growing out from the bone.

Destruction of cartilage in the regions of contact and pressure is usually brought about first by undermining subchondral granulations, which may be tuberculous in nature about the periphery of the cartilage, but which are non-tuberculous beneath the more centrally located portions of cartilage. There they consist of capillaries, fibroblasts and round cells, and in the capillary loops that invade and absorb the cartilage, polymorphonuclear leucocytes may be seen. They gradually detach the cartilage by absorbing articular bony cortex and the deeper portions of cartilage. As in pyogenic arthritis, whatever happens on one side of the joint usually happens on the other. If cartilage is preserved or eroded or undermined on one side the same condition obtains at points directly opposed.

These changes are well illustrated in Fig. 9. It shows the articular surfaces of the femur and tibia of a man whose knee was resected because of tuberculous arthritis of two and one-half years' standing. Cartilage is attached and preserved on the central portions of the surfaces of contact of femur with patella and of lateral condyle with lateral tuberosity, which is the point of greatest pressure in the joint. This is the region in the knee-joint where cartilage usually persists longest. It is detached and thinned by under-

mining granulations on the mesial condyle and tuberosity. It has been destroyed everywhere else in the joint except in these regions of contact, and they show marginal absorption. Figure 10 is a side view of the same specimens, with a sagittal section through the lateral condyle. It shows the preservation of cartilage and of articular cortex of bone at the points of contact of patella and of tibia with femur and the loss of cartilage and of articular cortex in the unopposed regions. The preservation of cartilage space and of articular cortex in the opposed regions is demonstrable in the röntgenogram taken before operation and shown in Fig. 11.

FIG. 7.—Röntgenogram of knee shown in Fig. 5. The ossified reparative tissue overgrowing the articular cartilage about margins of the regions of destruction cast disc-like shadows in cartilage spaces between condyles and tuberosities.

The first röntgenographic evidences of destruction of articular cortex in tuberculosis of the knee are usually seen along the free surfaces and about the margins of the articular surfaces. Preservation of both the normal width of cartilage space and shadow of cortex in the regions of contact and pressure is in favor of tuberculous arthritis, while loss in those regions with preservation elsewhere in the joint is in favor of pyogenic arthritis.

In those joints whose articular surfaces have like contour and in which cartilage fits snugly against cartilage throughout, leaving little or no unopposed surface, the loosening and destruction of articular cartilage is carried on mainly by the action of undermining granulations. This is true of the hip and ankle-joints, where, on opening the joint at the right stage, the cartilages may be found completely detached and considerably thinned from beneath, while there is little or no evidence of destruction along their free surfaces. After the disease is well advanced and destruction is extensive in the unopposed regions of the joint, the remaining cartilage in the opposed regions

may become necrotic. Cartilage is also killed *en masse* when the undermining granulations destroy its bony connections. In fact, the explanation of the development of the non-tuberculous subchondral granulations may be the necrosis of the cartilage without the entrance of tubercle bacilli into the subchondral regions. The granulations then form as a foreign body reaction to absorb and sequestrate the dead cartilage.

The experimental work of Nussbaum [4] supports the theory that articular cartilage, except the deepest layer, receives its nutrition from the synovial fluid. If the joint fluid continues to be the source of nutrition for the cartilage in tuberculous arthritis, it is understandable how, after the disease is well advanced, the altered exudate no longer furnishes adequate foodstuffs for cartilage and it dies *en masse* from lack of nourishment, as well as from the effect of tubercle toxins.

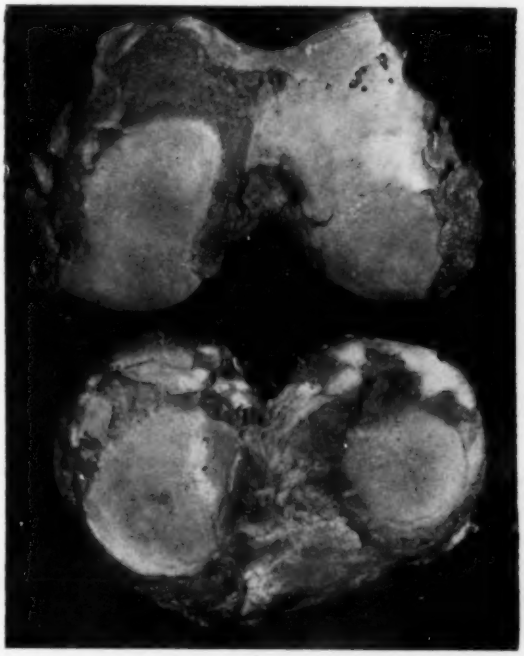

FIG. 8.—Tuberculosis of knee. Cartilage preserved where patella and tuberosities come in contact with femur and partly destroyed along unopposed surfaces of tibia and femur.

Dead cartilage, whether attached or detached, may persist in the joint for incredibly long periods, because of the absence of active proteolytic ferments in the tuberculous exudate. Pressure and motion erode and destroy dead cartilage. But when these are absent or slight, detached discs may persist for many months and dead cartilage may stand for years on articular sequestra, since granulations cannot get at its base to absorb it and there are no proteolytic ferments in the exudate to digest it. Edward Mueller,[5] Jochmann,[6] Opie and Barker,[7] and others have shown that exudates in tuberculous processes, including cold abscesses, contain practically no active proteolytic ferments, and we know that tuberculous granulation tissue is killed by coagulation necrosis, coagulins being formed by the tubercle bacilli (Ruppel,[8] Schmoll [9]) which precipitate the soluble colloids of the cells. The caseous areas persist for extremely long periods, because of the absence of active digestive ferments.

No published studies were found on the effect of tuberculous exudates on dead articular cartilage in relation to the persistence of cartilage in tuberculous joints. The digestive action of tuberculous exudates on cartilage was tested *in vitro*. Cold abscesses were aspirated and cartilage was incubated

at a temperature of 55 degrees C. in the fluid obtained. The tuberculous fluid coagulated in a short time, due to its richness in albuminous substances, and both articular cartilage and coagulum persisted after several days of incubation without any signs of digestion. This shows the absence of proteolytic ferment in the exudate. The tubercle bacillus is found to contain no proteolytic ferments and its toxins destroy the autolytic enzymes of the dead tissues. Consequently there is no autolysis of the dead cartilage. The leucocyte present in the tuberculous granulations and exudate is mainly the large mononuclear cell. It contains some proteolytic ferment, which is active in acid media, but not in tuberculous exudates, which are always alkaline in reaction (Opie and Barker [7]).

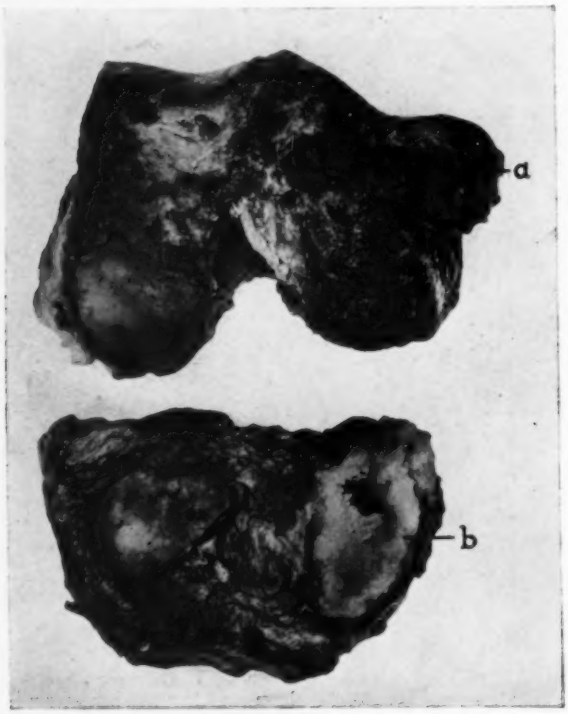

FIG. 9.—Tuberculous knee of two and one-half years' duration. Cartilage largely preserved at points of contact of patella and tibia with femur and destroyed elsewhere in joint. Contacting cartilage undermined on mesial condyle (a) and mesial tuberosity (b).

Figure 1 (b) shows cartilage unchanged and tuberculous fluid coagulated after ten hours of incubation. Figure 12 shows test tubes, 1, 2, 3 and 4, in which were placed equal sized pieces of cartilage. To them were added, respectively, salt solution, tuberculous pus, staphylococci suspended in salt solution and staphylococcus pus. They were incubated for 40 hours at 55 degrees C. The cartilage remained unchanged in the salt solution and in tuberculous exudate, and the latter coagulated; cartilage in the bacterial suspension was slightly reduced in size, while that in the staphylococcus pus was completely digested. The pus in tube 4 was much more liquid than it was at the beginning of the experiment.

The Effect of Pressure on the Bone in Tuberculous Arthritis.—Secondary invasion of the bone in tuberculous arthritis does not usually occur as long as the articular cartilage remains little disturbed. The non-tuberculous granulations which undermine the cartilage as the disease advances are superficial and rarely invade the bone to any appreciable extent. The tuberculous granulations which undermine the margins of the cartilage and attack the bone in regions where cartilage has been completely destroyed may invade the bone to some extent, absorbing it, with resultant pits and grooves in the bony surface. Secondary invasion of bone resulting in necrosis and sequestra is of rare occurrence in the regions of the joint that are not subjected to

pressure. While cartilage is usually protected and preserved longest at the points of pressure, the bone in these regions, after joint cartilage is largely or entirely destroyed, does not fare likewise. On the contrary, it is more subject to involvement than that in any other part of the joint. When cartilage has disappeared, the pressure and friction of bony surfaces may produce extensive bony erosion, as of femoral head and acetabulum at the hip, with pathological dislocation. Occasionally in weight-bearing joints, particularly the knee, there may be sclerosis of the bone to some depth and polishing of the bare bony articular surfaces at the points of weight-bearing. At an advanced stage there is not infrequently extensive secondary invasion of bone in the zones of pressure, either before or after their coverings of cartilage have been completely destroyed. Undoubtedly the damaging influence of pressure is instrumental in producing this invasion, and if the bone is invaded on one side of the joint, it is apt to be invaded on the other side. This results in necrosis of bone, and the areas are so large that the dead bone is usually not absorbed, but is gradually sequestrated. When the condition is bilateral, it produces "kissing sequestra." If cartilage is still present on the articular surface at the time of invasion, it will die and may subsequently be removed by erosion, or it may stand for a very long time, as granulations cannot readily get at it and the exudate does not break it down by proteolysis. The articular cortex is always preserved on the sequestrum, if cartilage is still present at the time of bony invasion. The sequestra usually show some evidence of bone atrophy, which had occurred from disuse before invasion and death of the bone. After death their density remains stationary, while that of the surrounding living bone is gradually reduced as the result of continued atrophy and absorption. In the röntgenogram such sequestra are recognizable by their density, which is greater than that of the surrounding living bone, and by

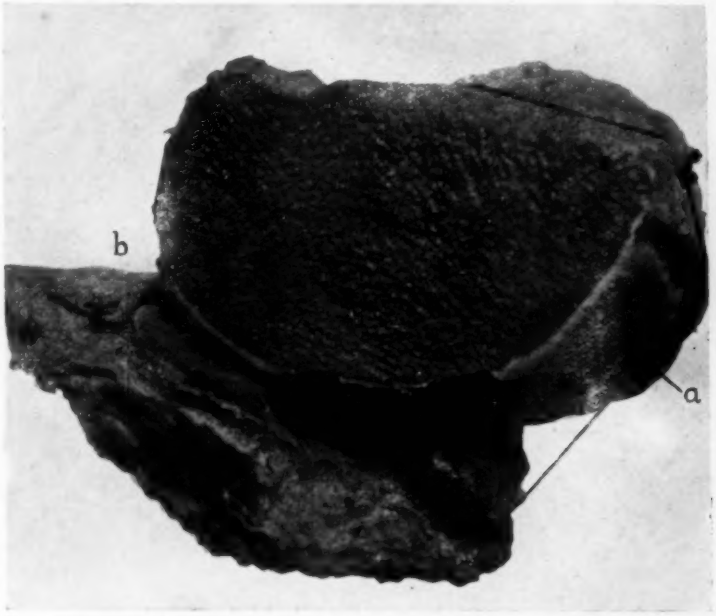

FIG. 10.—Lateral view of joint in Fig. 9 with sagittal section through lateral condyle, showing cartilage preserved in regions where femur came in contact with patella (a) and tibia (b). Cartilage destroyed elsewhere.

the presence of a shadow of articular cortex and sometimes of a zone of demarcation. If articular cartilage and cortex have been destroyed before bony invasion, there may be seen in the röntgenogram no sharp outline of the articular surface of the sequestrum. If bony sclerosis and polishing of the surface develop before bony invasion and death, the shadow of cortex and of underlying bone in the sequestrum may be very heavy. In fact, sclerosis may very rarely result in density which is greater than that of normal bone of the region. Occasionally there may be calcification of the necrotic tissue of the cancellous spaces of the dead bone, which may cause the sequestrum to cast a heavier shadow than normal bone of the region.

FIG. 11.—Side view of röntgenogram of joint in Fig. 9, showing cartilage space and articular cortex preserved in regions of contact of external condyle and tuberosity and of patella and femur, and articular cortex absent elsewhere.

Figure 13 is of a röntgenogram taken three years after the onset of tuberculous coxitis in a man, which had produced marked symptoms and had been treated by immobilization during the previous six months. At the top of the joint, which is its point of greatest pressure, there is an area in the head and one opposed to it in the ilium, which cast heavier shadows than the surrounding living bone and are separated from it by zones of demarcation. A definite, sharp shadow is cast by articular cortex on each dense area, while the shadows of articular cortex in the rest of the joint are absent. At operation by Doctor Ryerson extensive tuberculous coxitis was found. In the regions casting denser shadows there were two kissing sequestra. On each the articular cortex was preserved, and there was a thin layer of cartilage about the periphery of the much more extensive articular surface of the sequestrum from the head (Fig. 14). The findings indicate that articular cartilage was present on both areas when they were invaded and killed, and that the dead cartilage in the regions of contact of the two surfaces was destroyed by erosion, while that on the unopposed margins of the larger surface of the head was only partly destroyed. On microscopic examination evidence of slight atrophy of disuse was found in both sequestra, which indicates that an interval of time separated

the bony invasion from the onset of the disease. The presence of atrophy within the sequestra, their equal density, and their situation at the point of greatest pressure in the joint are conclusive evidence that they arose from simultaneous secondary invasion.

The presence of opposing sequestra in the knee-joint has been mentioned by Koenig [1] and Krause,[10] but an incorrect explanation of their development was given. Koenig assumed that one sequestrum represented the area of primary infection and that the other arose by secondary invasion across the joint after tuberculous arthritis had been established. No mention is made of the fact that they develop only in the regions of greatest pressure in the joint, nor was any comparison made of the pathological changes presented by the two sequestra. In a study of a comparatively limited number of joints operated on for advanced tuberculous disease, I have met with eight instances of kissing sequestra or opposed areas of necrosis in which sequestration was not yet complete. Seven were in the knee and one, the case above reported, in the hip. Detailed röntgenological and pathological examinations show that in every instance the bony invasion occurred simultaneously and secondarily on the two sides of the joint. That the lesions developed simultaneously is shown by the fact that the pathological changes are exactly the same on the two sides. They each present the same degrees of density and of destruction. If articular cortex is present on one, it is present on the other also. If dead articular cartilage is found on one, it is found on the other, unless the articular surfaces are of unequal size, in which case cartilage may be absent from erosion where the surfaces of the sequestra come together, but present on the unopposed portion of the larger surface.

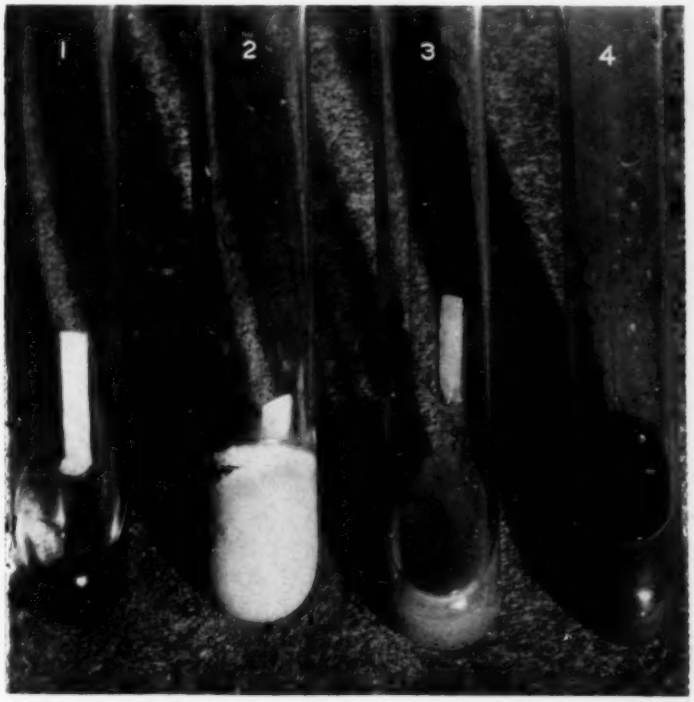

FIG. 12.—Cartilage digestion experiment. Equal sized pieces of cartilage incubated at 55 degrees C. for forty hours in normal salt solution (1), tuberculous pus (2), staphylococcus suspension (3) and staphylococcus pus (4). Cartilage unchanged in (1) and (2), slightly changed in (3) and completely destroyed in (4). Tuberculous pus (2) was coagulated and staphylococcus pus (4) was liquefied.

That both sequestra arose secondarily is shown by a number of facts. Since the pathological evidence indicates that the two lesions arose simultaneously, it is evident that they are either both primary or both secondary osseous involvements. It is inconceivable that bacteria from the blood stream would so often lodge at the same time in the bone underlying directly opposed surfaces of the joint, and always in the regions of greatest pressure. Microscopic examination of the sequestra showed evidences of atrophy of the bone before its death. In some cases the atrophy was slight, while in others it was very marked and equal to that in the surrounding living bone. The necrotic bony areas may be found attached to the surrounding living bone, with few signs of absorption and sequestration about their margins. This is evidence of recent invasion, and when the dead bone is also atrophic, the secondary nature of the lesions is definitely established.

The shape of an area of necrosis is variable. It may be that of an oval or often that of a low cone with its base bordering on the joint. Since Koenig's publications it has been the custom to regard all cone-shaped areas of necrotic bone with their bases on the articular surface as the result of embolism, clumps of tubercle bacilli, either alone or in tuberculous debris, lodging in end arteries of the epiphysis and infecting the area supplied by the obstructed artery. The recent work of Nussbaum,[11] showing that the arteries of the epiphysis, unlike those of the metaphysis, are not end arteries, has cast doubt on the correctness of this theory. It is readily apparent that areas of necrosis from secondary invasion of the bone have been confused with those from primary hematogenous invasion. Some authors, as Nichols,[12] have claimed that practically all tuberculosis of the joints arises by extension from a primary focus in the adjacent bone, and they cite the presence of sequestra and necrotic bony areas as the most important evidence in favor of the contention. The mere presence, along the articular surface, of a sequestrum or of a cavity remaining after necrotic bone has been absorbed, is not proof that the primary infection was in the bone. Careful examination from the standpoints of location, density, bilateral involvement and amount of sequestration will show that many of these bony lesions are the result of secondary invasion.

The following is another case in point: Male, age sixty-eight, had mild tuberculous arthritis of the knee for fourteen years, during which time he received no treatment and worked on the limb continuously. The symptoms then became markedly aggravated, and Fig. 15 shows the appearance of the joint in the röntgenogram eight months later. The joint was then resected, and two opposed areas of bony necrosis were found in the region of contact of mesial condyle and tuberosity, as shown in Fig. 16. That the bony invasions were approximately simultaneous and of recent date is evident from the fact that the density of the bone in the two necrotic areas and in the surrounding living bone is the same and is considerably less than normal. Gross and microscopic examinations of the regions involved showed only partial sequestration of the dead bone and an equal degree of atrophy in the dead and living bone. The röntgenographic features of tuberculous and pyogenic arthritis have been described elsewhere in greater detail. (American Journal of Röntgenology and Radium Therapy, July, 1924.)

In case of cold abscess and fistula formation in tuberculous joints, there may be invasion and infection by pyogenic organisms, greatly complicating the pathological picture. After pyogenic arthritis has been engrafted on tuberculous arthritis, the destructive effects of the former may be seen in the regions of contact and pressure and all articular cartilage killed *en masse* by the tuberculous process may be rapidly destroyed. However, tuberculous joints with fistulæ of even long standing very frequently show no evidence of secondary pyogenic infection.

FIG. 13.—Tuberculosis of hip, showing two kissing sequestra at point of greatest pressure in joint.

Bearing of Pressure on Treatment.—It is readily seen from the pathological changes in articular surfaces that contact and pressure have a bearing on treatment, and that it is different in pyogenic from what it is in tuberculous arthritis.

In pyogenic arthritis the aim of treatment should be to limit and to overcome the infection and to preserve motion. The agencies which assist in the realization of one of these aims may be helpful, indifferent or harmful in the realization of the other. Pressure exerts an unfavorable influence on the spread of the infection, inasmuch as it disposes to invasion and destruction of articular surfaces at points of contact; and destruction of articular surfaces disposes to the development of ankylosis. Pressure is increased by weight-bearing and by marked effusion in the joint, distending the capsule and forcing articular surfaces together. Pressure may be relieved to some extent by drainage and by extension. Drainage acts beneficially by permitting the escape of noxious and of necrotic substances, to a slight extent by the relief of pressure. Incision should be adequate for the degree of the infection, and should be

resorted to oftener than is commonly practised in the milder cases. The danger of aggravating a severe turbid serous or seropurulent arthritis by arthrotomy plus careful post-operative dressings, except in the presence of severer neighboring infection, as osteomyelitis, has been exaggerated. Limitation of motion following loss of articular surfaces at the points of pressure only may be lessened or obviated in this way. The insertion of a drain is unnecessary where the overlying soft parts are thin, but where thick, as at the hip or shoulder, a tube should be inserted and its end sutured to the synovia. Excepting in very mild cases, pyogenic arthritis should be treated during the active stage of the disease by extension, unless it is impractical because of the location of the joint or the presence of neighboring disease. In view of the pathological changes that result from pressure, it would seem good practice to diminish or if possible entirely relieve it by extension, unless there are very strong arguments to the contrary. The main argument to be advanced against extension is that it interferes with motion. Moving the joint acts beneficially by increasing drainage and by obviating continuous pressure of opposed articular surfaces in one region. Willems [13] has advocated motion and when possible weight-bearing at every stage of arthritis, because they assist in drainage. It should be remembered that, in general, motion is harmful to infected tissues and that friction and pressure of opposing articular surfaces favor cartilage destruction. Does the advantage of drainage derived from pressure by weight-bearing outweigh the advantage of protection of articular cartilage derived from extension, and is the increased drainage produced by motion more beneficial than rest? It is a curious fact that almost no mention is made by Willems of the pathological changes that may occur in the articular surfaces and of the influences they may have on the therapeutic result, particularly as concerns mobility of the joint. It is impossible to conclude from Willems'

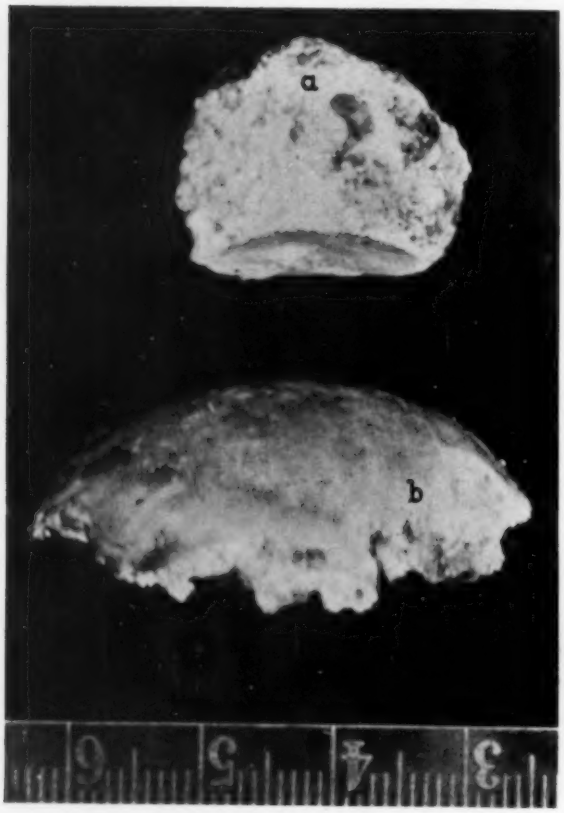

FIG. 14.—Photograph of kissing sequestra shown in Fig. 13, (a) from ilium and (b) from head.

writings whether he holds that if one follows his methods there will be no pathology in the articular surfaces or that, regardless of the extent of changes from the infection, his methods will give a better functional result than any other.

It would appear that rational management of pyogenic arthritis consists in early and free drainage and, whenever possible, extension of the joint. Mobilization with the weight lifted should be inaugurated as soon as one feels that it will be tolerated. Whether or not it should be carried out from the beginning of treatment is a question that is still open for debate. Mobilization in arthritis is often very difficult to carry out, because of the severity of the general condition, as sepsis, or of the regional condition, as osteomyelitis, of which it is a complication. In general, mobilization should be started only after the peak of the acute infection has been passed, and extension should be continued along with it until general symptoms have partially subsided and the discharge has become slight and has lost its purulent nature. By that time the danger of augmenting by pressure the infection of articular surfaces has passed and motion for the purpose of restoring function may be pushed to the limits of toleration. Röntgenograms of joints in continuous extension show that it is difficult to procure any appreciable amount of separation of articular surfaces unless considerable weight is applied. With light weight extension pressure between apposed joint surfaces may still be sufficient to cause greater breaking down there than elsewhere. Thus in a case of suppurative arthritis

FIG. 15.—Tuberculosis of knee of fourteen years' standing in sixty-eight year old man. Secondary kissing sequestra, seen in Fig. 16, in mesial condyle and tuberosity, not recognizable in röntgenogram because both the dead and the surrounding living bone were equally atrophic.

of the hip-joint drained two weeks from the onset (during which time there must have been considerable necrosis of joint surfaces) there was later röntgenologic evidence of progressive destruction of the upper part of the head and of opposed acetabulum despite the fact that an eight pound weight extension was kept up during the ensuing six weeks.

In the treatment of tuberculous arthritis there is more variation of opinion, both as to aims that should be sought and as to the methods of achieving them, than is the case in the treatment of pyogenic arthritis. By operative treatment one generally aims to obtain healing with bony ankylosis, which, once established, is the surest safeguard against recurrence. By non-operative measures the majority of surgeons try to obtain healing with the greatest possible limitation of motion, preferably with ankylosis, while a few strive for healing in some cases with preservation of motion. Pressure plays a rôle in the non-operative treatment, in that it modifies the time and manner of cartilage destruction, and after cartilage is destroyed it disposes to erosion or extensive invasion and necrosis of bone to which it is applied. By leading to extensive necrosis of bone followed by sequestration, it may create the necessity for operative interference in the course of conservative treatment.

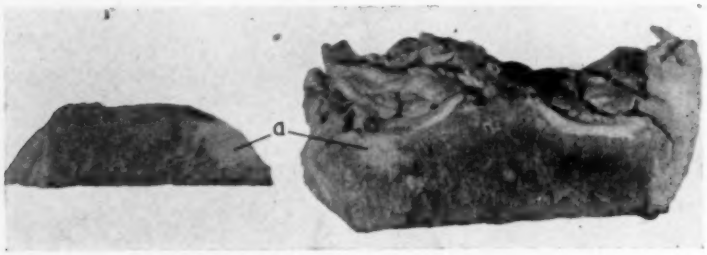

FIG. 16.—Resected specimens from joint in Fig. 15. Coronal section through tibia and sagittal section through mesial condyle, showing kissing sequestra (a) where it and mesial tuberosity were in contact. The necrotic areas of bone atrophic and partially sequestrated, showing recent development.

Immobilization without extension of the joint in the earlier stages of tuberculous arthritis should theoretically be the best method for preservation of cartilage at the points of contact and pressure. Extension would tend to pull the surfaces apart and in that particular would enable the granulation tissue to get at and destroy more of the articular cartilage. As previously stated separation by extension is difficult of accomplishment. At the same time extension brings into play the favorable factor of fixation, which tends to lessen the extent of the tuberculous changes. This makes it difficult to estimate the separate effects of extension and of fixation on the articular cartilage. If preservation of articular cartilage is what is desired, there are in the pathological findings certain grounds for believing that it is more likely to be realized from fixation alone than from fixation plus extension. Surely, those who argue that if extension is not applied, articular cartilage will soon be destroyed in the regions of contact and pressure are in error. There seem to be perhaps equally good grounds for arguing that if extension is applied, articular cartilage will be destroyed earlier than usual in those regions, because then the granulations would have a better chance to get at its surfaces. It is

even possible that some of the beneficial effects derived from extension have come from this more rapid loss of cartilage, which puts the joint in a more favorable condition for the occurrence of ankylosis. Theoretically, it would appear that healing with motion is more apt to come from the treatment of early tuberculous arthritis by immobilization alone than by extension, because immobilization alone is more apt to preserve cartilage, and preservation of cartilage is a prerequisite for motion. Lorenz and others claimed improved results from treatment by immobilization plus weight-bearing in tuberculous arthritis of the lower extremity. If this is right, it should be worth while to investigate whether the extra pressure of weight-bearing is the beneficial factor, and, if so, whether it acts by hastening the destruction of articular cartilage or by assisting in its preservation. Once articular cartilage is destroyed in a case of tuberculous arthritis, extension would seem a rational procedure, if the disease is progressive, since it should then protect the bone from erosion or extensive invasion with sequestration at the points of pressure.

Further röntgenological and clinical observations made with the anatomical changes herein noted kept in mind, should throw additional light upon the influence which pressure has upon the therapeutic results in both pyogenic and tuberculous infections of joints. They should be made on patients treated with and without extension and with and without weight-bearing.

CONCLUSIONS

1. In pyogenic arthritis articular cartilage is killed and broken down first at the points of contact and pressure of opposing articular surfaces.

2. In tuberculous arthritis articular cartilage is not killed first, but is protected at the points of contact and pressure of opposing articular surfaces. Cartilage is extensively destroyed first along the free surfaces, where the tuberculous granulations can grow onto and remove it. It usually disappears last in the regions of contact and greatest pressure in the joint, where it is detached and killed by undermining granulations and is then partly eroded by pressure of opposing bony surfaces.

3. Proteolytic ferments derived largely from polymorphonuclear leucocytes assist greatly in the rapid removal of necrotic cartilage in pyogenic arthritis. Proteolytic ferments are absent in tuberculous arthritis, and masses of dead cartilage may persist for months or years, showing few signs of progressive destruction.

4. In pyogenic arthritis the infection rarely invades secondarily the deeper portions of the bone at the points of pressure.

5. In tuberculous arthritis invasion of the bone at the points of pressure is of common occurrence after the articular cartilage has been largely or wholly destroyed. The invasion is frequently on both sides, in which case it may lead to the formation of kissing sequestra at the points of greatest pressure in the joint.

6. Weight extension should be applied during the active period of pyogenic

arthritis to lessen the amount of invasion and destruction of articular surfaces at the points of contact and pressure.

7. On the other hand, it would appear that extension for preventing the destruction of articular cartilage in tuberculous arthritis is not indicated. But when articular cartilage has already been destroyed, extension should lessen the tendency to erosion or invasion with sequestration of bone at the points of greatest pressure in the joint.

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ENTEROSTOMY AS A THERAPEUTIC AND DIAGNOSTIC MEASURE*

By Miles F. Porter, M.D.
of Fort Wayne, Ind.

Experience and observation have taught me that enterostomy might, with advantage be resorted to much more often than it is. The term "enterostomy" is here used to signify opening of any part of the intestinal tract regardless as to whether or when closure is to follow. Not as frequently as was the case a few years ago, but still all too frequently, the surgeon is confronted with patients dying from obstruction of the bowel consequent upon an acute abdominal infection in whom the paramount indication is relief of the abdominal distention and drainage of the intestine, and in whom care of the focus of infection for the time being is of secondary importance and because of the desperate condition of the patient would better be left to be dealt with later. The following case, reported in brief, is but one of a number occurring in my practice which illustrates the point:

Mrs. A. was seen at her home in the country at night in extremis from bowel obstruction consequent upon acute puerperal infection. Extreme abdominal distention, leaky skin, vomiting, weak and rapid pulse were the outstanding symptoms. The pelvis was doughy but there was no fluctuation. A rapid enterostomy done with the patient in her bed was followed by prompt improvement and three days later the pelvic abscess discharged per vaginum. Complete recovery with closure of the enterostomy followed.

Enterostomy in an obstructed loop of intestine prior to removing the cause of obstruction will frequently aid in determining whether or not excision is necessary, will lessen the danger of fatal toxæmia following relief of the obstruction, and make the relief of the obstruction much easier.

Given a volvulus or strangulated hernia wherein the viability of the involved bowel is questionable, opening and draining the gut helps one to determine more quickly and certainly for or against excision and removes the danger of toxæmia from the passage of the stagnant content through the remaining part of the gut.

Again in a case of obstruction without strangulation, enterostomy and drainage of the obstructed gut removes the danger of toxæmia and facilitates completion of the operation. I have a strong feeling, prompted by considerable experience, that many of the deaths following operation for bowel obstruction might be prevented by opening and draining the obstructed bowel of its contents *before the obstruction is removed.*

The danger from soiling the wound may be avoided in large measure and is not as great as is the danger from absorption of long obstructed bowel content.

* Read before the American Surgical Association, April 17, 1924.

SUMMERS[1] of Omaha and JUDD and RANKIN[2] of the Mayo Clinic have recently published valuable papers on this topic. According to W. J. Mayo,[3] Sir William Taylor "has had noteworthy success in handling acute obstruction of the bowels using enterostomy for the purpose of emptying the toxic contents of the bowel and of nourishing the patient." ORR and HADEN in a paper read at the 66th annual meeting of the Missouri State Medical Association on the "Treatment of Intestinal Obstruction" say "It is probable that we sometimes do a complete operation when an enterostomy would be the wiser procedure. In the very toxic cases the least operation possible to relieve the obstructed bowel, the better. If a bowel will not empty through a good enterostomy opening it will not empty through the natural bowel channel which has been relieved of the obstruction. If an operation for the complete relief of the obstruction, whether it be freeing of a constricted gut, a resection or an anastomosis, is not considered advisable, an enterostomy should be done.†

In previous communications I have cited cases illustrating the difficulty of distinguishing between malignant and benign disease of the hollow viscera even with the abdomen open. In the one case reported[4] the pyloris was the part involved, and in the other paper[5] four cases are reported wherein non-malignant disease of the colon was mistaken for malignant disease. In three of these cases recovery followed colostomy and in the fourth the growth was excised and an artificial anus made. In this case after the growth was found to be benign the artificial anus was closed. In the pyloric case a gastro-jejunostomy was done as a palliative measure—which "palliative measure" proved curative and the patient reported himself well after four years and eight months. All of these cases were reported by members of this body, two by the writer and three by men of exceptionally high standing. James C. Masson of the Mayo Clinic regards the advice of Telling, Erdman and others to operate in all cases of diverticulitis as "most radical."[6] Of the 289 cases diagnosed in this clinic only 116 were operated upon.

I have no hesitancy in predicting that in the near future resection for diverticulitis will be rarely done. Evidence is accumulating to prove that many cases of chronic diverticulitis of the sigmoid and rectum even with tumor formation and symptoms of obstruction can be cured by colostomy. That colostomy should usually precede resection in those cases demanding this latter operation is I assume an established surgical rule. How far the fear of malignancy should lead us in favor of resection as the treatment of choice in certain of these cases is as yet an open question.

Masson says that malignancy and diverticulitis are frequently associated and that the malignancy is no doubt the result of the infection. That colostomy is frequently postponed and in some cases permanently rejected, because of the disagreeable features it entails, to the great detriment of the patient is not an uncommon experience.

The disagreeableness of an artificial anus has been much exaggerated. Is there a surgeon within hearing who does not know of patients who were

† After this paper was finished I read Horsley's paper (Journal American Medical Association, April 12, 1924, p. 1159) in which he advises enterostomy after resection of the colon. He says: "Patients in whom the colon has been resected make a much smoother convalescence when this enterostomy is done."

subjected to a so-called radical operation for colonic or rectal cancer because of the "disgust and horror" which the thought of colostomy aroused in the mind of the patient or surgeon or both when as the sequence proved the minor operation offered much more hope for the prolongation of life and promotion of comfort? Colostomy properly done in properly selected cases adds to the comfort, contentment and pleasure of the patient. Gant [7] reports that 70 per cent. of his colostomized patients have but one movement a day within a month after the operation. My aim in this paper has been to show that the danger and inconvenience of enterostomy have been exaggerated; while the benefits to be derived therefrom have been underestimated and that a correct valuation with consequent modification in surgical procedure would be beneficial.

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INTRA-ABDOMINAL RUPTURE OF INTESTINE FOLLOWING STRANGULATED FEMORAL HERNIA*

By Frank LeMoyne Hupp, M.D.
of Wheeling, W. Va.

Better understanding of the abuse of taxis and the crime of delay in strangulated hernia, together with the early recognition and prompt surgical intervention, have diminished the frequency of bowel gangrene and its direful sequelæ.

Many valuable contributions are found in the earlier literature telling the story of delay and describing intestinal "wet death" within the hernial sac, but in general there is little information to be found bearing upon that more serious complication mentioned in the title of this paper. A. J. McCosh,[1] in 1889 collected and tabulated one hundred and fifty cases for which immediate resection was done. C. L. Gibson's [2] statistical study based on "A Thousand Operations for Acute Intestinal Obstruction and Gangrenous Hernia," supplied a need at that time which had hitherto not been met. Neither of these interesting communications makes mention of an intra-abdominal rupture of the constricted gut.

A reference of historical interest from the writings of the English anatomist, John Hunter,[3] bearing on this subject, which reflects his own wide experience, is worth quoting here. He writes:

"It is very curious to observe in hernias, that while the gut is in the sac and alive, no inflammation takes place within the sac or integuments; but the moment the gut becomes mortified or dead, the stimulus of an extraneous body takes place immediately; an outlet is then endeavoring to be made by the inflammation and suppuration of the sac, forming an abscess in it; which matter with the contents of the gut, is brought to the skin. While this is going on, the sound gut within the abdomen where it passes into the rings, adheres to those rings all round; so that when the abscess is formed, burst, or opened, and the mortified parts sloughed off, these ends of the gut open into the abscess, and not into the cavity of the belly."

In an effort to ascertain the frequency of a complete severence of the gut at the point of constriction within the abdomen, an abstract of the author's findings was sent to Sir Berkeley Moynihan, who courteously replied:

"I have had a number of cases of strangulated hernia in which the intestine has given way at the line of constriction. It has happened more often with femoral than with inguinal hernia. In their treatment, as a rule, the intestine is pulled down into the hernial sac, a resection made and an end-to-end anastomosis by suture completed. We have notes of three cases in which a fecal fistula was formed by merely laying open the adherent intestine in patients extremely ill. In two of these closure occurred after the spur between the two limbs had been destroyed by pressure. We have no note of any case in which fecal extravasation occurred into the peritoneum, as in your case."

W. B. Coley, whose wide experience at the Hospital for Ruptured and Crippled is well known, in a personal communication writes: "From my own

* Read before the American Surgical Association, April 17, 1924.

experience as well as my knowledge of the literature of hernia, I know of no case quite similar."

It is reasonable to assume that accidents of this character have been observed before; however, the literature available contains the record of but one case clearly belonging to this category. This was reported by T. H. Manley [4] before the Pan-American Medical Congress, November, 1896.

CASE I.—(Manley's case.) Male, Chinaman, aged twenty-eight years. No previous history of importance except a reducible inguinal hernia of the right side, of eight years' duration. No truss had been worn for three months. One morning the hernia descended and was more painful than usual; repeated efforts failed to reduce the mass. Medical aid was not sought for four days. The patient was in a state of grave shock and exhaustion when he presented himself for treatment.

Operation.—The sac was widely opened and found to contain a large quantity of dark offensive fluid, exposing a strangulated and gangrenous coil of the terminal ilium, completely severed at the distal constriction, about five inches from the ileocæcal junction. The wound was enlarged so as to freely expose the right lower abdominal quadrant. Foul-smelling fluid and contents of the bowel had been extravasated, and an acute peritonitis was in evidence. An immediate resection of twenty-six inches of the intestine was made and a lateral anastomosis performed, the Connell technic being employed. The upper part of the abdominal wound was closed, while the lower part, with the scrotal incision, was left wide open and packed loosely with gauze; no radical cure of the hernia had been attempted. The recovery of this remarkable case was uneventful.

CASE II.—C. W. G. Male, age fifty-seven years. Referred to the writer's service in the Ohio Valley General Hospital by Dr. Myron K. Reppard, November 12, 1919. For several years the patient had been subject to mild attacks of indigestion, and was conscious of an irreducible lump in his right groin. This lump was manifestly an incarcerated femoral hernia and was so diagnosed by his family physician. There was no other previous morbid personal history. Three days before admission he developed acute tenderness and pain in the right groin, with nausea, and persistent vomiting, and he then noticed an appreciable increase in the size of the protrusion. Efforts to move the bowels were fruitless and taxis was of no avail. The pain which was at first local became general and was described by the patient as "doubling up," and rendering him "unconscious."

Physical Examination.—The patient was a poorly nourished white man, appearing ten years older than his fifty-seven years. The countenance was drawn and anxious, skin moist, pulse frequent and small, respirations shallow and costal. He lay with his knees drawn up, apparently free from pain, except on palpation of the abdomen. There was entire absence of splenic and hepatic dulness. Over the right saphenous opening there could be felt a protrusion, immovable and semifluctuant, and about the shape and size of an egg. There was absolute stomach intolerance, the ejecta was brownish and foul. The clinical picture was obviously one of strangulated femoral hernia, associated with peritonitis. While this of itself was grave enough from the beginning, it was further complicated by shock, which had suddenly developed in the course of an extremely rough trip of seventy miles while in transit from his home to the hospital. The imperative necessity for immediate surgical interference was obvious.

Operation.—A preliminary gastric lavage was done. Under nitrous-oxide and oxygen and local blocking an incision over the protrusion was made. This revealed a loop of lustreless, black and lifeless gut, about 10 cm. in length. A foul-smelling, dark-colored fluid, containing fecal matter, escaped from the sac. At the point of constriction one end of the devitalized loop was wide open, and the segment from which it was separated was nowhere to be seen. The constriction was divided and a liberal incision made through the rectus muscle, freely exposing the right iliac fossa. The open and retracted

proximal end of the terminal ileum was then identified. It exhibited a sharply defined area of pressure necrosis and an extension of the gangrene about 3 cm. beyond the point of rupture. The adjacent mesentery was thickened, with evidence of clotting in the vessels. The abdominal cavity contained fecal matter, free fluid and gas, and the presenting intestinal coils were studded with a fibro-purulent exudate, confined for the most part to the right lower abdominal quadrant. The distal end of the gut with the gangrenous loop was withdrawn through the femoral ring. Fourteen centimetres of the ileum were resected at a point 45 cm. from the ileocæcal junction. A precautionary mattress stitch was inserted, followed by an end-to-end reunion of the intestinal continuity, by the use of a Murphy button. The cut edges of the mesentery were approximated by interrupted stitches of fine chromic gut. After a careful peritoneal toilet, and well-directed drainage, the abdominal incision was partly closed. The original incision over the hernial protrusion was loosely packed with washed iodoform gauze. Inspection of the resected segment of gut showed two small ulcerations about 1½ cm. in diameter; one within the lumen and a second distal to the constriction. The ulcers were not perforated.

Progress of the Case.—The patient responded to measures directed against the shock. The presence of hiccough was an embarrassing feature for twenty-four hours, but it finally yielded to gastric lavage. There was a gradual abatement of all distressing symptoms, and a free evacuation of the bowels on the fourth day. The patient's convalescence was uneventful, and he was discharged well from the hospital on the twentieth day. The button was passed on the thirtieth day and he has continued in good health to the present time.

Mechanical Devices in Anastomosis.—In the light of the increasing opposition to the use of mechanical aids in effecting an intestinal reunion, perhaps some apology is due for the selection of the button in this instance.

Thirty years ago Caird [5] of Scotland observed that the best results in surgery of the intestine could be gained with needle and thread; and he prophesied that many of the ingenious inventions employed in uniting the bowel would share the fate of the too greatly neglected device of Quatre Maitre, who, in the 13th century, employed a calf's trachea for a purpose similar to that which led Ramhdor to use a tallow candle and Senn to employ decalcified bone plates. Certainly no protest need be made when the gravity of the case demands speed, if the Murphy button forms a part of the emergency equipment, even though we concede with Moynihan that all mechanical devices "have now no more than an historic interest."

Primary Reunion or Artificial Anus.—One's first impulse in such an emergency is to make an effort at conservation of the patient's resources, and to establish an artificial anus, rather than add further to the already exhausted invalid by any tedious sewing. When planning for this less serious procedure it is well to remember that the patient must later be subjected to an operation having a mortality of 27 per cent. (Gibson), in the restoration of the continuity of the gut, and that the making of an artificial anus is but "one step on a perilous road to recovery," as Singly has so fittingly put it. On the other hand, it must be remembered that immediate primary union, when properly done, consumes little, if any, more time, whether effected by suture or by a mechanical device. Gibson, in a very complete résumé, quoted by Johnson,[22] found in one hundred and one cases in which an artificial

anus was formed there were fifty-three deaths, a mortality of 52.5 per cent. In 226 cases in which primary resection and reunion of the intestine was made at the time, there were 58 deaths, a mortality of only 26 per cent. Further supporting this contention is the interesting fact that the elder Kocher and Mikulicz were ardent champions of primary resection, while Coley's [6] statistics, collected from six of the larger clinics, and based on an analysis of 3268 cases, show a mortality of 23 per cent. in favor of immediate reunion. However, on last analysis each case must be determined on its own merits.

Infrequency of Femoral Hernia in the Male.—Regarding the infrequency of femoral hernia in the male, in 61,561 males with hernia in the groin, reported by Gibson [2] from Maydl's series, 2362 were femoral, or as 1 to 25. Hoguet [7] in giving his observations on 2468 hernia operations, found but one case of strangulated femoral hernia in the male.

Ulceration, Gangrene or Perforation of the Bowel Beyond the Hernial Constriction.—Whipple [8] and his associates attribute the overwhelming depression and death in these cases of obstruction, to an excessive breakdown of tissue protein due to the absorption into the blood of a toxic proteose. Werelius [9] is inclined to the opinion that it is a liver inefficiency or a cessation of bile secretion, which has a direct bearing on the mortality factors. Lynch [10] and Draper [11] and Eisburg [12] contend that the lethal agent is due to an interference with the internal secretory function of the epithelial cells of the gut itself, rather than to bacterio-toxic causes, or of biochemical origin similar to parathyroid or other endocrine secretion. Moynihan [13] has written that the mechanical impediment to the onward flow of intestinal contents is not so much the cause of the collapse of these patients, as the overloading, distention, and the ulceration of the gut above the block, together with the absorption of contents whose bacterial virulence is greatly increased. The last thought opens up a new field, as the ulceration beyond or proximal to the constricted loop, to which the distinguished English surgeon refers, goes on to perforation and fatal peritonitis, unless promptly recognized and relieved. The literature contains several timely reminders of this type of hernial complication, and as some of the cases so nearly parallel the author's report, with your indulgence, they will be included in this discussion.

Case I.—S. Hida,[14] while operating for a strangulated inguinal hernia, found the bowel in the hernial sac black and devitalized. The compression anæmia and gangrene were found to extend six centimetres above the seat of the constriction and in this area, above the stricture, there were two perforations, and a generalized peritonitis. Thirty-six centimetres of the bowel were excised and anastomosis made by suture. Repair of the hernia was effected by the Bassini method, and the patient made an uninterrupted recovery.

Case II.—Goodhart [15] describes a case in a woman aged forty-four years, who was operated upon in Guy's Hospital, London, for a femoral hernia, in 1879. Readmitted two years later, because of recurrence of the hernia and persistent vomiting. She was operated upon again, a mass of omentum being removed and the stricture divided. She died twelve days later, the abdomen becoming distended and painful; the temperature was normal until the day before death, then rose to 102° F. The knuckle of bowel involved in the hernia was close to the cæcum. At autopsy an ulceration affecting 12 to

13 feet of bowel extended upward from the incarcerated bowel, which was not ulcerated. The ulcers were arranged in clusters forming more or less circular patches, extending all around the bowel, though more mesenteric than otherwise. The cause of the ulceration could not be determined as no obstruction to the circulation could be found.

CASE III.—In a review of 1500 inguinal hernia operations at the Massachusetts General Hospital, Boston, Mass., LINCOLN DAVIS[16] notes that there were eight deaths. One of these was a case of double hernia, in which abdominal pain, distention and vomiting developed after the hernia operation. At a second operation on the eighth day perforated ulcers of the colon were found. Necropsy showed no direct connection between the hernia operation and the peritonitis, which was evidently the result of the perforation of the intestinal ulcers.

CASE IV.—SELLENINGS[17] reports two cases in which perforation above the hernia occurred prior to operation. In one case the patient was a woman with a history of left-sided inguinal hernia of many years' standing, for which a truss had been worn. The hernia became irreducible and very painful, but within a few hours the patient reduced the mass herself. After the reduction she felt severe abdominal pain, chiefly in the region of the umbilicus, vomited several times and was prostrated. The temperature was 101.6° on admission to the hospital; the abdomen was distended, rigid and tender. At operation a round, solitary perforation of the ileum was found, and about eight to ten inches distal to the perforation the gut was contused, showing signs of recent strangulation. The perforation was sutured, but the hernia was not repaired, owing to the patient's condition. The patient vomited frequently during the first few days after operation, but made a good recovery.

CASE V.—SELLENINGS' second case occurred in a man who had a right inguinal hernia for two years and had worn a truss. On the day of admission to the hospital the hernia came down into the scrotum, and was painful and tender. He also had colicky pains in the abdomen but did not vomit. The abdominal pain became very severe and he was sent to the hospital during the night; the abdomen was moderately distended, rigid and tender, especially around the umbilicus. The scrotal tumor was painful on pressure, but was reduced by manipulation. Temperature 102.8° F. At operation a single perforation was found in the intestines similar to the one in the previous case. The gut distal to this lesion showed no gross alteration indicating that the compression had not been so great as in the first case. The perforation was sutured; the hernia was not repaired; the patient recovered.

CASE VI.—MACNAUGHTON[18] reports a case of left inguinal hernia in which no attempt at reduction was made. The patient was relieved by hot fomentations and the administration of morphin followed by a small enema, which caused a movement of the bowels. Later the patient became restless, and fainted when attempting to sit up; the pulse was weak; the extremities became cold, and he died in a few hours. At autopsy an irregular transverse rupture was found in the small intestine in the left lumbar region; for fully four feet below this level the ileum, until it passed into the hernial sac, contained blood and mucus. The hernial sac contained nearly three feet of healthy small intestine, the cæcum with an elongated vermiform appendix, five inches of the ascending colon, and a considerable portion of the mesentery; there were no signs of strangulation.

CASE VII.—MOIR[19] reports a case in a man who had had inguinal hernia for six months, for which he wore a truss. On the night prior to admission to the hospital the hernia had come down and could not be as easily reduced as usual. The patient finally succeeded in reducing it, and almost immediately after felt abdominal pain and vomited. When admitted to the hospital the next day the abdominal pain was severe, and the patient was in a state of collapse. At operation a perforation in the small intestine was found, and below it a slight constriction of the gut. The perforation was sutured, a careful toilet of the peritoneal cavity made, and a drainage tube inserted into the pelvis. The patient did not rally and died about four hours after the operation.

CASE VIII.—J. F. ERDMANN[20] reports a case of non-reducible umbilical hernia in a young woman who had a history of abdominal pain, distention, and hiccough persisting for about a week. At operation, the intestines above the hernia were found to be matted together, and a slough was found at the proximal and the distal end of the jejunum. Ten inches of intestine were excised and suture anastomosis made. The patient made a good recovery.

In presenting this subject THEODORE KOCHER[21] suggested the possibility that in strangulated hernia, as in other forms of bowel constriction, the intestinal wall above the lesion may be involved. He believed this was due primarily to venous stasis coming from an interference with the circulation, thus decreasing the resistance of the mucous membrane to the invasion of bacteria and leading to ulceration, or even to perforation.

This ulceration of the mucosa, whatever its cause, seems to present a definite pathological entity, and we believe that a note of warning should be sounded against any anastomosis being attempted in a case of strangulated hernia with gangrene, without first carefully inspecting the two segments of the gut, with reference to the integrity of the mucous membrane.

The various theories advanced regarding the lethal agent coming as a sequel of intestinal block, whether it is the ulceration or trauma of the mucosa, suggested by Moynihan, dehydration, proteose intoxication, or the invasion of hæmolytic bacterial flora. Each has its supporters, and valid reasons have been presented, based on painstaking research. Whatever the source of the complex biochemical formula, whose venom will produce a clinical picture so grave and a pathology so destructive, we do know that it makes speedily for *exitus lethalis*, unless promptly recognized and relieved.

In conclusion, it may be mentioned that in dealing with a strangulated hernia, with death of the bowel, there are at least two mortality factors to be considered in addition to the shock occasioned by the intestinal block:

First.—The possibility of an intra-abdominal leak, due to a partial or a complete rupture at the point of the constriction from pressure necrosis.

Second.—There may be further added a definite pathologic entity in the form of an ulceration of the gut, leading to a post-operative perforation. That this accident has been recorded with increasing frequency, and this fact should lead to a searching interrogation of the mucous membrane immediately adjacent to or beyond the line of anastomosis, in order to forestall a potential leakage.

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THE ADDITIONAL POSTERIOR INCISION IN CERTAIN CASES OF OPERATION FOR THE INFLAMED RETROCÆCAL APPENDIX*

By Willy Meyer, M.D.
of New York, N.Y.

There can be no question that it is to the advantage of the patient under operation, if the surgeon can see plainly what he is doing. Starting from this premise, I have made it a rule in my personal work, even as far back as the early times of the evolution of the appendix chapter, thirty years ago, to expose to view the inflamed organ in its entire length in the course of its extirpation. I never practiced the method of working through a small incision and trying to separate adhesions bluntly by the mere sense of touch, when operating for appendicitis.

I have applied this rule also to the so-called retrocæcal appendix, when the latter is tied down and cannot be brought into view by any kind of manipulation.

In this type of cases I have found it expedient, and to the best interest of patient as well as surgeon, to abandon the anterior incision, para-rectal or per-rectal, and add a posterior one which exposes the retrocæcal and retrocolonic space.

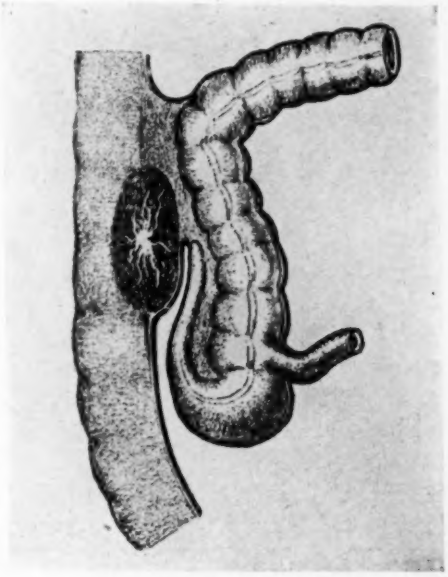

Fig. 1.—Reproduced from G. S. Hunt'ngton, l. c. Tip of retrocæcal appendix reaches level of right kidney, but is completely covered with peritoneum. In such an instance the surgeon usually is able to mobilize the inflamed organ and make its distal end appear alongside the ascending colon.

If McBurney's intermuscular operation had been in progress, then the additional posterior incision was made a part of the former.

Every surgeon has met with instances in which the appendix could not be brought forward and properly exposed for the usual tying of the meso-appendix and consecutive steps. He then follows downward to the cæcum the presenting longitudinal band of the ascending colon. But not infrequently just the very base of the appendix alone appears, its further course, for the moment, is not discernible. Then, on lifting the caput coli with the left hand and slipping the right forefinger around the cæcum we often feel the mass behind the gut. In many cases when the organ lies entirely within the

* Read before the American Surgical Association, April 17, 1924.

peritoneal cavity (Fig. 1)† we succeed in pushing it forward and bringing its tip into view, which then renders easy the completion of the operation. In other instances the manœuvre is unsuccessful. Inflammatory bands of old standing are unyielding; firm adhesions make the appendix absolutely immovable, it forming a unit with the intestine, or congenital anatomical relations hold it fixed posteriorly (Figs. 2 and 3).

In such an emergency, in acute and sub-acute as well as chronic cases, the surgeon has to decide quickly as to the best and safest procedure in the given case.

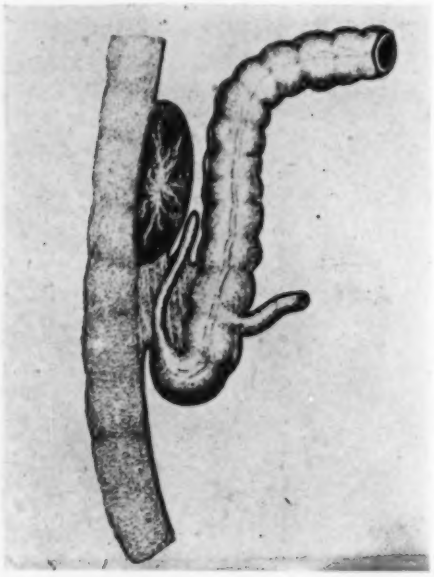

FIG. 2.—See G. S. Huntington, l. c. The greater portion of the retrocæcal appendix, commencing at its base, runs upward toward the kidney within the retroperitoneal tissue, its distal third, however, is situated within the general peritoneal cavity, a fold of peritoneum, descending from above, covering it all around.

Personally I believe it is to the patient's interest not to insist upon forcing the further steps of the operation by way of the original incision, but to place a sand-bag under the patient's right hip and proceed as follows: map out the middle between McBurney's point and the anterior superior spine by placing thumb and third finger on these two points and the forefinger upon the centre of the imaginary line, connecting the umbilicus with the anterior superior spine, and from here make a second incision upward through the skin toward the region of the kidney, about 2½ to 3 inches long (Fig. 4). After dividing the fascia of the external oblique muscle and its muscular substance in the same direction, the fibres of the internal oblique are cut across, bleeding vessels being immediately caught and tied. Transverse fascia with parietal peritoneum appears, in stout patients clearly marked by a layer of fat; they are also cut. Now the retrocæcal and retrocolonic space has been opened and its condition can be explored under the guidance of the eyes. Usually I have made this wound of the abdominal parietes funnel-shaped, the deep incision shorter than that of the skin, in order to cut across as few fibres of the internal oblique as possible. I always open the peritoneal cavity in the lower angle of the wound, because the entrance into the peritoneal sac at this place is assured. According to requirement the whole incision can be lengthened upward in the course of the further work. With the borders of the wound well held apart by means of broad blunt retractors, the appendix usually comes quickly into view and can now be followed up in its entire course to its tip, and be safely

† Ileocæcal folds and fossæ in George S. Huntington, The Anatomy of the Human Peritoneum. Plate cclxxxi, p. 272.

and correctly dealt with. For the effect of the additional posterior incision it is immaterial whether the appendix is completely or only partially located intraperitoneally. The point is, to be able and expose the organ in its entirety, irrespective of its length and course. That can be nicely accomplished with the help of the additional posterior incision.

If McBurney's intermuscular operation had been done, the posterior incision starts from the middle of the superior lip of the transverse muscular and peritoneal wound and runs from there upward (Fig. 5), the inner and outer end of the original peritoneal incision having been marked by clamps which are left temporarily in place. Drainage and closure of the posterior wound is done according to general rules. If in acute or subacute cases pus was encountered, due to gangrene, with an infiltrated mesoappendix, the cigarette drain will be a safeguard, as in other cases of acute appendicitis, and the desired drainage is facilitated on account of the directly downward course of the canal, the patient being on his back. In the absence of gangrene we close up completely by means of layer sutures. The anterior wound is always closed airtight.

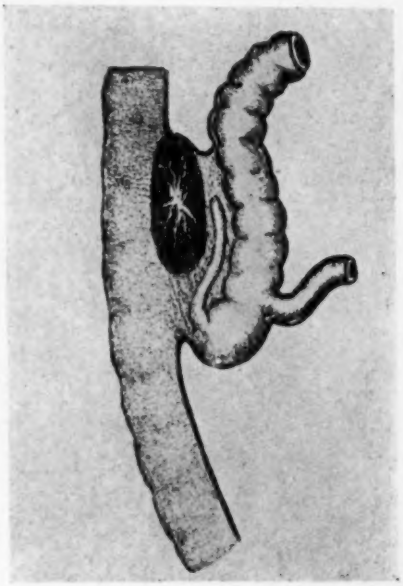

FIG. 3.—Also copied from G. S. Huntington, l. c. The entire long retrocæcal appendix is situated outside of the peritoneal sac; its tip again reaches up to about the middle of the kidney. Blunt manipulation from within the peritoneal cavity, without guidance of the eye, must necessarily represent a hazardous surgical procedure.

I first mentioned this procedure, which I did not find described in the literature when discussing Dr. A. S. Vosburgh's paper, "Non-rotation of the Intestine; Its Relation to High Retrocæcal and Aberrant Position of the Appendix," read before the New York Surgical Society on October 9, 1912 (ANNALS OF SURGERY, December, 1912). Later on I elaborated on it in the "Festschrift," dedicated to Prof. F. Trendelenburg by his former assistants and his successor in the Chair of Surgery at the University of Leipsic on the occasion of his seventieth birthday ("Zur Chirurgie des Wurmfortsatzes," Deutsche Zeitschr. f. Chir., vol. cxxix, p. 321, 1914).

On November 5, 1920, I read a paper on the same subject, entitled "A Safe and Simple Method for the Extirpation of the Adherent Retrocæcal Appendix" before the Surgical Section of the New York Academy of Medicine. This has not been published so far. A recent instructive personal experience brought the value of the additional posterior incision, as above described, again forcibly to my mind and impelled me to write this paper and discuss the method before our Association. I prefer not to cite this last case in spite of its many points of interest, because it was somewhat atypical and did

not, owing to pathologic peculiarities encountered, show *all* the advantages of the additional posterior advance, as I had seen them in previous experiences. I shall therefore pick out for illustration just a very few cases from a series of upward of thirty of this type, that have been operated upon by me on basis of the above-cited plan within the last twenty-eight years.

According to my personal records, the additional posterior incision for an adherent retrocæcal appendix was done by me for the first time in 1896. As a matter of evolution variations of the operation were developed according

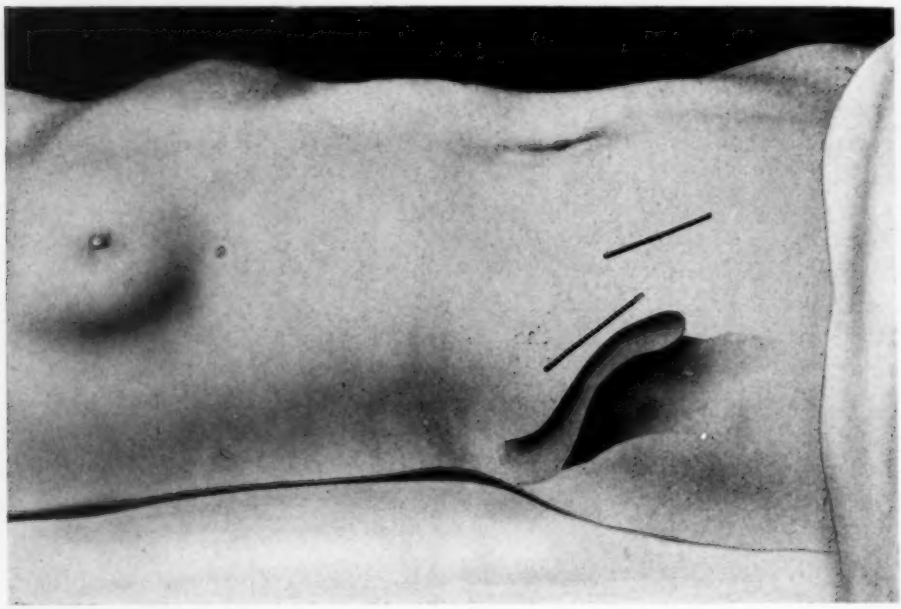

FIG. 4.—Showing the two incisions as used by the author in cases of adherent retrocæcal appendix which cannot be properly reached and loosened from the front. The one nearest the middle line represents the typical pararectal incision, which is abandoned in case of necessity, the second then being added; the lower end of the latter corresponds to the middle between McBurney's point and the anterior superior spine and then runs backward and upward as long as required, dividing the muscles sharply.

to the character of the inflammation—acute, sub-acute, chronic—as well as to the possibility of a correct diagnosis previous to operating regarding the position of the inflamed organ; that is to say, in a number of instances access was gained by means of the posterior incision primarily, sharp through all the muscles, or by the intermuscular approach, at the place and in the direction mentioned above for the additional posterior incision, or by a high intermuscular approach according to McBurney (Fig. 6) leaving out the preliminary entrance into the abdominal cavity from the front. The variations are:

1. Anterior incision with additional lumbar cut;

2. McBurney's intermuscular operation with additional sharp incision backward and upward from the middle of the upper lip of the musculoperitoneal wound;

3. Primary McBurney intermuscular incision, high above the omphalospinous line, without the necessity of an additional posterior incision;

4. Primary posterior sharp incision through all the three muscles constituting the abdominal wall.

The two latter varieties will not be discussed here.

CASE I.—*Para-rectal or per-rectal incision plus additional lumbar incision.* Male, forty-eight years. In May, 1904, sudden severe colic, rectospasm, vomiting. Admitted to the Lenox Hill Hospital, ten hours after the onset of the attack.

Operation.—Para-rectal incision; appendix not found; incision lengthened upward; cæcum high; insertion of appendix exposed, runs in retrocæcal direction; extensive adhe-

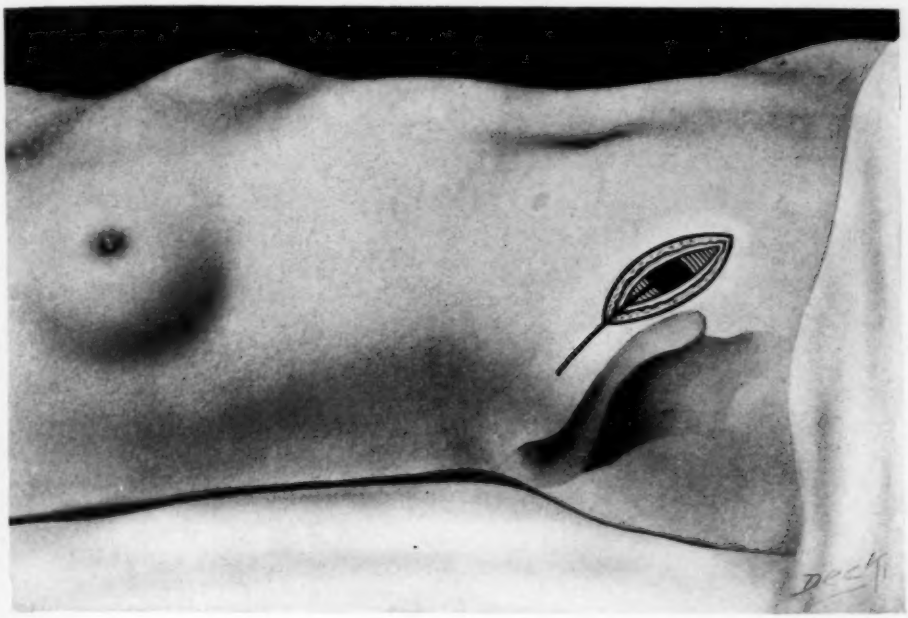

FIG. 5.—Typical McBurney incision which, in spite of being lengthened intermuscularly, does not give proper access in order to completely expose a long appendix which runs behind of and upward with cæcum and ascending colon. The same incision is added as shown in Fig. 4 commencing at the middle of the upper border of the exposed and separated muscle substance. It will permit to do any work required under the surgeon's eyes, no matter how long, twisted and adherent the appendix.

sions; discontinuance of operation by this route; temporary tamponade; right side of pelvis raised upon sand-bag; sharp incision backward through the three muscle layers (as above described), which had gradually to be lengthened to the anterior tip of twelfth rib; with a second cushion placed under the lumbar spine, producing pronounced lordosis, the entire very long appendix comes finally into view; from its insertion into the cæcum it turns backward and upward toward the renal region; thence toward the middle line and from there downward again close to its starting point, thus describing about nine-tenths of a circle. Ligation of old strong adhesions step by step; appendectomy; suture of wound; cure.

CASE II.—*Perforative gangrenous appendicitis.* Female, thirty-five years. Great sensitiveness over McBurney's point, extending upward toward border of liver. Admitted to Lenox Hill Hospital, October. 27, 1905. Para-rectal incision; peritoneal cavity filled with pus; appendix does not come into view on pulling upon cæcum. It is therefore assumed that the organ is located retrocæcally. Additional posterior incision with sharp division of muscles, as in preceding case. Appendix seen at once; very long; firm adhesions to posterior surface of ascending colon; tip near liver found to be gangrenous and perforated; suture with drainage; cure.

CASE III.—*Acute gangrenous appendicitis.* Male, twenty-seven years. Seriously ill for twenty-four hours; tenderness posteriorly and in front; some rectospasm. Admitted to Lenox Hill Hospital, May 20, 1919. Immediate operation: Para-rectal incision; only base of gangrenous appendix visible; organ retrocæcal and firmly adherent; additional posterior incision exposes a totally gangrenous appendix; removed without breaking the organ; anterior and posterior cut closed; rubber tissue drain in upper end of lumbar wound; uninterrupted recovery.

CASE IV.—*McBurney's blunt intermuscular incision with additional sharp incision backward and upward from the middle of the upper lip of the muscular wound.* Boy,

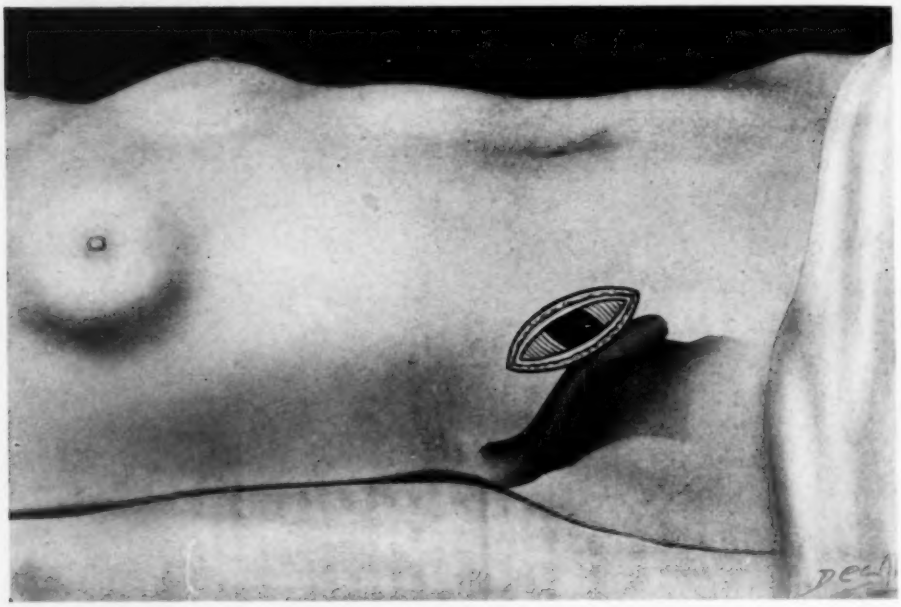

FIG. 6.—A high McBurney incision; the lower end of the wound corresponds to the omphalospinous line. It will permit to thoroughly expose to the inspection of the surgeon the appendix which is situated retrocæcally, provided it does not run too far upward, and cæcum with colon are movable. If need be, the upward sharp incision can be added as shown in Fig. 5.

twelve years; interval operation at Lenox Hill Hospital, May 14, 1901. McBurney's blunt, intermuscular division; cæcum not found, even after placing patient in Trendelenburg's posture; intermuscular incision continued inwardly (Weir); wide access; sigmoid flexure to the right; cæcum away up, tightly adherent; appendix runs posteriorly and upward, equally firmly adherent; impossible to reach for good surgical work; therefore posterior incision through muscles added; organ now fully accessible; thickened firmly adherent to intestine and omentum; loosening; excision; suture; cure.

CASE V.—*Acute appendicitis.* Male, twenty-five years. Two weeks previously peculiar attack of intra-abdominal inflammation. Diagnosis of appendicitis doubted by attending physician on account of the alleged absence of tenderness over McBurney's point. Moderate sensitiveness posteriorly at time of consultation. Diagnosis: Appendicitis; organ situated posteriorly. Operation, December 12, 1906, at the Lenox Hill Hospital. Blunt division of muscles (McBurney) above anterior superior spine; appendix does not come into view; finger palpates organ tightly adherent posteriorly; on attempting to loosen it, pus appears; incision lengthened inwardly (Weir), good access; but appendix cannot be reached as yet; closure of inner two-thirds of wound; sharp division of muscles posteriorly and upward, with sand-bag under right half of pelvis. It becomes evident that a perityphlitic abscess had advanced posteriorly into the lumbar

muscles, the suppurating canal being about two inches long; appendix itself very short, funnel-shaped at insertion near cæcum, contains thin fæces; excision; drainage; recovery.

Of course, the surgeon can try in cases of this type, to do away with the sharp division of the posterior abdominal wall in one and the same line and proceed by means of a high placed McBurney's intermuscular operation with Weir's addition, for a wide exposure is usually required. However, cases will be encountered as I have just described them, where the cæcum is situated so high that even a *very* wide intermuscular approach will still be found insufficient and the sharp division of the muscles upward will become imperative. And it may be done without hesitancy, because neither important nerves nor blood-vessels are cut. Personally I have not observed a subsequent abdominal hernia in a single instance, even when, in former years, wide drainage with gauze tampons was done. The careful suture of the wound in layers with the insertion of a cigarette drain or a twisted piece of rubber dam, as practiced nowadays, makes the development of an abdominal rupture well-nigh impossible. In one of the cases the local tonus of the abdominal wall was found to be impaired, evidently on account of the division of branches of the twelfth intercostal or the ileo-hypogastric nerve which cross the field; here the right hypogastric region was somewhat bulging for a while, but a hernia did not develop. Such sequelæ, of course, can sometimes not be avoided and must be faced, when difficult, life-saving work is to be safely carried out.

In emergencies, such as described, some surgeons practice primary division of the base of the appendix, as mentioned above, and after proper attendance to its stump, follow the course of the organ toward its tip. I have tried this myself, but cannot see any advantage in such a course. It certainly is always the better plan to try to work from the tip to the base and after complete exposure make the division of the base of the appendix the last step of the operation. In particularly difficult cases this procedure will also not lead to a successful removal of the entire appendix, except the parietal peritoneum alongside the large intestine is divided. Others abhor the idea of making a second abdominal incision in an operation for appendicitis, no matter how complicated the case may prove to be. They cut through the fold of the parietal peritoneum parallel with and on the outer side of cæcum and ascending colon. This allows the operator to pull the large intestine inward and turn its posterior side up. However, it seems to me that this procedure is far less advantageous for the patient, surely less advantageous in case of acute gangrenous inflammation of the retrocæcal appendix with perforation and pus formation. Such an incision along the outer side of the gut enters the retroperitoneal space and is bound to open new avenues for absorption and possible additional infection at a time when nature, in many instances to be sure, had just succeeded in closing them, due to the intense inflammation present. Besides—and this is the principal drawback—such incision intentionally unites the general peritoneal cavity, which in some cases

so far was but slightly or not at all involved, with the region of the source of inflammation. Whereas, by adding the second, posterior incision, we reach the focus of intensest disease by the shortest and most direct route. We are able to loosen and remove the appendix, no matter how long and twisted it may prove to be, with ease and precision, watching every step, without coming in contact with the general peritoneal cavity, and we can drain, should this appear necessary, in a most direct and natural way.

Proceeding as above described, the surgeon will often be surprised to observe how the removal of a firmly adherent inflamed retrocæcal appendix which, at first glance, appeared to be a difficult and complicated task technically, with one stroke becomes transformed into a comparatively easy and safe operation.

AN EXPERIMENTAL CONSIDERATION OF THE INFECTION OF PERMANENT HYDRONEPHROSES*

By Vernon C. David, M.D.

and

E. C. McGill, M.D.

of Chicago, Ill.

The underlying cause in the development of a hydronephrosis is generally recognized to be any factor that causes obstruction to urinary outflow from the kidney or ureter. This obstruction may be complete and constant, in which event a permanent hydronephrosis develops, or it may be transient or incomplete when an intermittent or moderate hydronephrosis is present. In either event, the obstruction to free urinary outflow is one of the chief factors in causation of infection of the urinary stream, it being necessary only to add the offending organism to produce the picture of a urinary tract infection of mild or severe type. In view of the many and varied causes of hydronephrosis, varying from an aberrant renal vessel or a congenital ureteral valve to absolute obstruction of the ureter, it is the purpose of this paper to study some of the factors which may be of importance in converting a relatively harmless hydronephrosis into a pyonephrosis.

In order to have a fixed condition to study, we have elected to consider infection of hydronephroses due to complete obstruction of the ureter rather than the intermittent or incomplete types, though the principles governing the infection of all types are more or less the same. Clinically, the permanent hydronephroses are usually due to accidental or purposeful ligation of a ureter during an operative procedure in the pelvis, pressure on the ureter from inflammatory masses or any growths, stricture of the ureter, obstruction by stone, products of inflammation or congenital anomalies.

Barney [1] was able to collect 46 cases from literature where ligation of the ureter had been performed. Ten of these patients recovered without symptoms of any sort. Thirty of the patients recovered after a stormy convalescence which required nephrectomy in seven of them. Six of these patients developed an infection of the hydronephrosis which required the nephrectomy. As these cases are rather difficult to find in literature and complete data was present only in the operative cases that required nephrectomy, the fate of the kidneys in the remaining thirty-nine cases is problematical. From the standpoint of our subject it is of great interest to know that about 15 per cent. of the cases of accidental ligations of the ureter in patients resulted in infection of the hydronephrosis. From the experimental standpoint, a great deal of data is not available as to the spontaneous infection of hydronephrosis after simple ligation. In some work of our own, where ligation and division of the ureter had been accompanied by division of the cord at different levels,

* Read before the American Surgical Association, April 19, 1924.

we frequently had infection of the hydronephrosis, when the operative wound over the spine became infected. We were able to ascertain that as a rule the organisms found in the pyonephrosis were those which were present in the wound infections of the back.

FIG. 1.—Dog 7-7. Twelve-hour hydronephrosis after ligation of ureter. A. Normal kidney. B. Beginning hydronephrosis.

In the case of five other dogs who died after ligation of the ureter in a period varying from eight days to two months after the ligation, and in which no conditions had been introduced to favor infection of the urinary stream, spontaneously developing pyonephrosis was found in two. One of these dogs died of distemper four weeks after ligation of the ureter. Fine bacilli commonly found in distemper animals were isolated from the hydronephrosis. In the other animal dying two months after ligation of the ureter, Gram-positive bacilli and Gram-negative cocci were found in the pyonephrosis. In contrast, an animal dying of pneumonia five weeks after ligation of the ureter, had a sterile hydronephrosis.

These few clinical and experimental observations are of importance in that they show that the infection of a complete hydronephrosis occurs in a definite percentage of cases.

The experiments to be discussed in connection with this problem will consider contiguous intraperitoneal infections as well as the relation of the bowel and blood stream to infection of hydronephroses.

Ascending Infection of a Possible Route for Infection of a Hydronephrosis.—The description of well-defined lymphatics in the wall of the ureter connecting the bladder and kidney has served as an argument to establish the premise that kidney infections may result from the infection travelling from the bladder to the kidney by way of the ureteral lymphatics. I believe this rarely happens and that the lymphatic drainage of the urinary tract is segmental, the bladder and lower ureter draining into the hypogastric glands and the upper ureter and pelvis of the kidney into glands along the vena cava near the hilum of the kidney.[2]

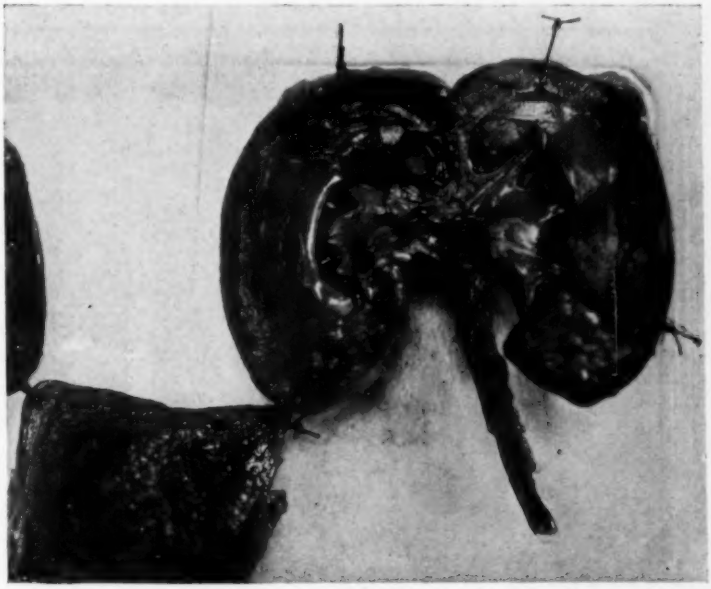

FIG. 2.—Dog 20. Five-day hydronephrosis after ligation of the ureter.

If, however, due to accidental ligation and division of the ureter in the course of a pelvic operation the stump of the ureter comes in contact with infectious material, the possibility of infection of the developing hydronephrosis arises. This infection theoretically may involve the kidney by ascending infection through the ureteral lymphatics, by direct extension of the infection through the ureter or by involvement of the blood stream.

To establish experimental conditions which would enable us to evaluate these possibilities, sixteen dogs, whose urine was known to be sterile, were used. In some of the animals a plastic exudate on the peritoneal surface of the bladder was induced by the colon bacillus. The ligated divided ureter became adherent to this plastic exudate on the bladder in several dogs. These dogs were sacrificed from four to twenty-three days after the experiment had started. The post-mortem revealed a sterile hydronephrosis in six dogs, although a rather marked polymorphonuclear exudate was present in the peri ureteral tissue around the blood-vessels, frequently reaching to the sub-pelvic kidney fat. In two other dogs (6 days and 23 days) B. coli pyonephrosis had developed, though the opposite kidney urine, as well as the blood stream, was sterile. In these experiments the obvious inference is that the cut surface of the ureter coming in contact with infectious B. coli exudate resulted in an ascending infection which in two dogs resulted in a pyonephrosis.

In contrast to these experiments are those in which a piece of gauze saturated with B. coli was wrapped around the undivided ureter. In these

experiments very little or no evidence of involvement of the ureteral lymphatics was found and the urine in the kidney remained sterile. In other experiments, where a pelvic abscess was formed about B. coli impregnated gauze, and the ligated cut end of the ureter was incorporated in this abscess, pyonephrosis was usually present after two to four weeks. In these animals it was difficult to say whether the infection had been caused by direct extension of the infection by continuity, or had spread to the kidney urine *via* the lymphatics, or was the result of a blood stream infection. My impression is that lymphatic involvement was not responsible for the infection in this group of animals.

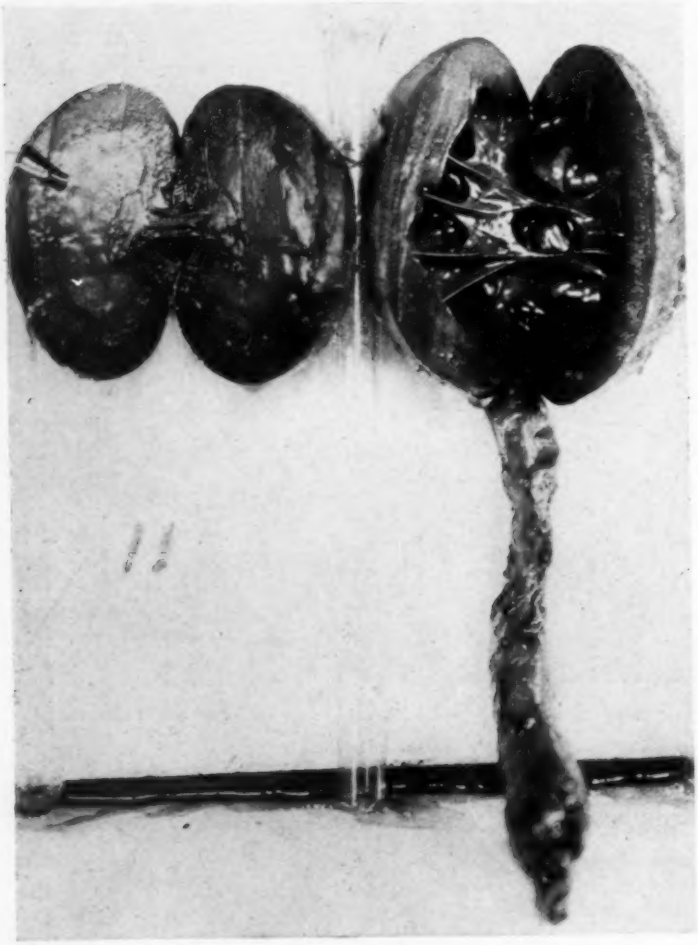

FIG. 3.—Dog 11. Six-day hydronephrosis after ligation of ureter and control kidney (A).

In general, it may be said that a hydronephrosis developing because of a ligated, divided ureter may become infected *via* the ureteral lymphatics if the cut end of the ureter is in contact with infectious material. I do not believe that this route is a common one or that it compares in frequency to infection of the urinary tract by other routes.

The Relation of the Bowel to B. Coli Infection of Developing Hydronephroses.—There are several clinical and anatomical facts that point to the bowel as a possible source for B. coli which are so commonly found in urinary tract infections. B. coli have been isolated from the blood during the process of infectious diarrhœa. Pyelitis in children has been noted most frequently

with the incidence of summer diarrhœa. Several authors have mentioned the occurrence of constipation in pyelitis cases.

Anatomically, Franke [3] has described lymphatics connecting the bowel and right kidney and though he demonstrated these fine lymphatic connections in but 20 per cent. of the bodies examined, the theory of passage of organisms from the bowel to the right kidney has been rather firmly established in urological literature. In reading Franke's articles on this subject, and in studying his drawings of injected lymphatics between the cæcum and the right kidney capsule, the possibility of infection of the kidney by continuity from a diseased appendix or inflamed bowel adherent to the peritoneum over the kidney, is obvious. It is questionable, however, how possible it is for infection to travel by the lymphatics from the bowel to the kidney if there be no gross lesion of the bowel or inflammatory process in the bowel which would cause adherence of the bowel to the kidney capsule. It is questionable because the lymphatic vessels between the bowel and kidney capsule are very small, relatively few in number, and inconstant. The lymph flow from the intestine and

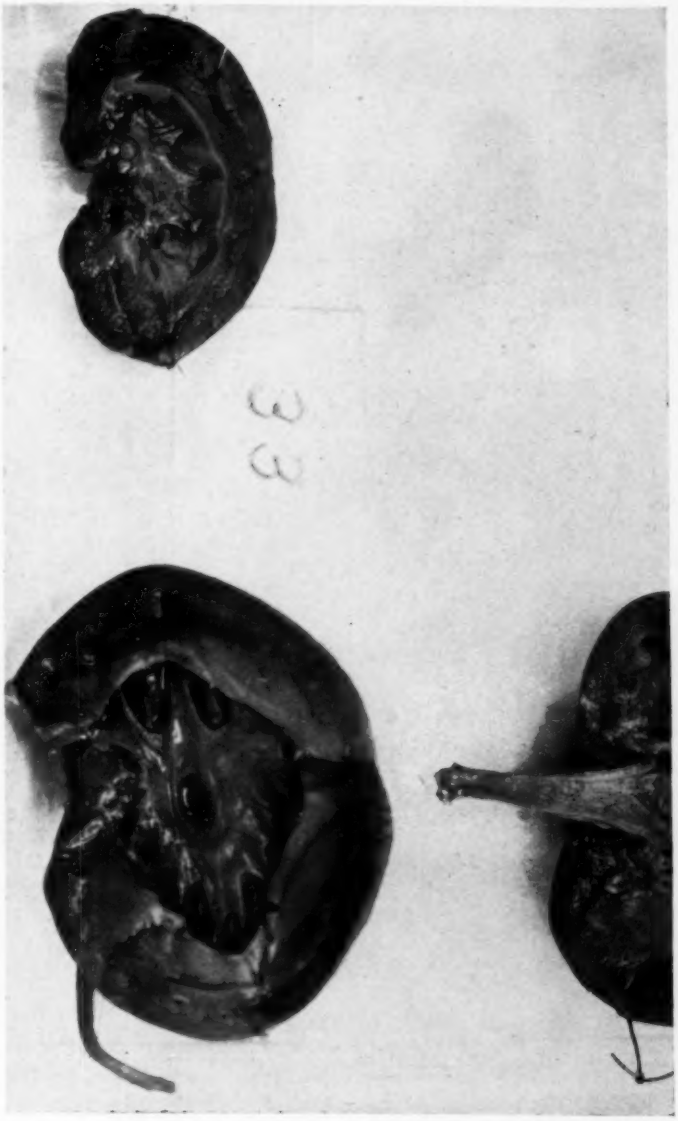

FIG. 4.—Dog 33. Six-day hydronephrosis after ligation of ureter and control kidney.

appendix is to the mesenteric glands and not toward the kidney. Lastly, it is not definitely known that organisms leave the normal or slightly damaged bowel to gain access to the lymphatics other than the mesenteric glands. The presence of organisms in the mesenteric glands is by no means synonymous with kidney infection or blood stream infection.

The striking work of Ravenel,[4] Calmette,[5] and Griffith,[6] on the passage of tubercle bacilli and pigment through the normal bowel mucosa makes it seem very probable by analogy that other bacteria might penetrate the normal mucosa of the bowel. Thiele and Embelton,[7] von Picker,[8] and others have reported experiments which seem to favor the point, while Opitz,[9] and Neisser,[10] in carefully conducted work throw great doubt upon it.

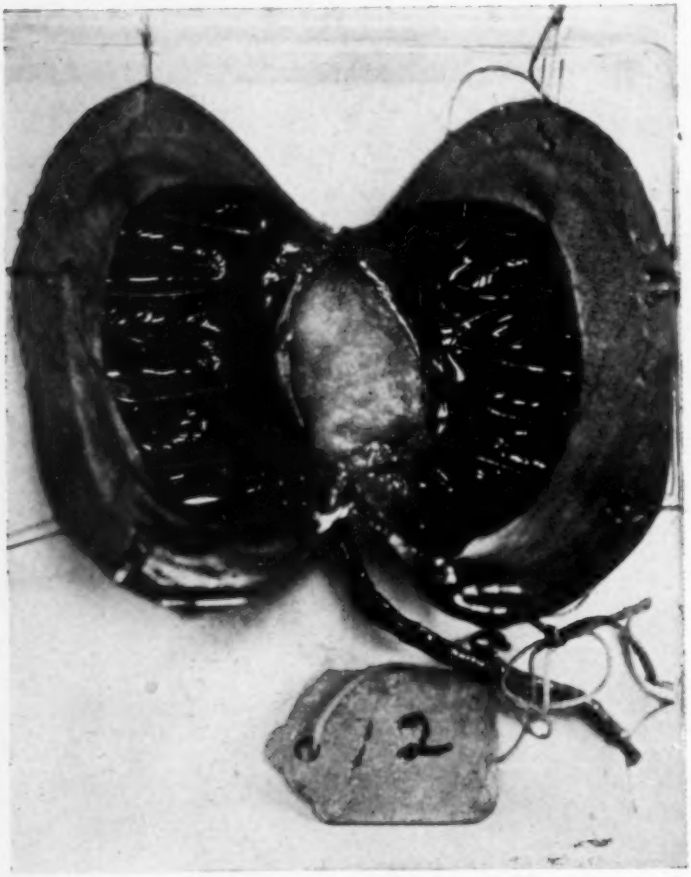

FIG. 5.—Dog 12. Eleven-day hydronephrosis after ligation of ureter.

Author's Experiments on Dogs.—Experiments were conducted on thirty-seven dogs to study the possibility of the passage of bacteria, especially the colon bacillus through the normal and pathological bowel wall to the mesenteric glands, to the blood stream, or directly into the urinary tract through the lymphatics. A hydronephrosis was established on the right side by ligation of the ureter, to serve as a filter for any organisms reaching the urinary tract on that side. Controls were studied and experiments conducted to ascertain the effect of introduction of large amounts of actively growing B. coli into the intestinal tract of dogs during fat digestion, during periods of marked constipation or prolonged diarrhœa, and after obstruction or traumatism of the bowel.

Injection of B. coli into the mesenteric glands, and transplantation of

impregnated B. coli gauze into the mesenteric glands was carried out to attempt infection of the hydronephrosis *via* the lymphatics.

In obtaining material for culture at post-mortem, the abdomen was opened with sterile surgical technic. Bladder urine, right hydronephrotic urine and left kidney urine were taken for culture. Tissue culture of the mesenteric glands, kidney parenchyma and liver parenchyma were made by putting the tissue through a sterile Rosenow grinder and using the tissue emulsion in ascites bouillon and ascites blood for culture. Hearts blood was used for culture. Culture of the urine by aspiration from bladder was obtained by exploratory laparotomy in practically all experiments and all dogs with organisms in their urinary stream were excluded.

FIG. 6.—Dog DD. Two weeks hydronephrosis after ligation of ureter.

As the details of the experiments have been published elsewhere, only the conclusions derived from them will be given.[1]

(1) In control dogs with normal intestines, the mesenteric glands contain bacteria in over 50 per cent. and contain B. coli in 33 per cent. of the glands examined. These facts speak conclusively for the passage of organisms from the normal bowel to the mesenteric glands.

(2) Injection of large amounts of actively growing B. coli into the normal gastro-intestinal tract of dogs was associated with the presence of B. coli or a B. coli-like organism in the urinary tract of three of eleven dogs. It is probable that these organisms reached the urinary tract by way of the blood

stream. The lowered resistance of these animals afflicted with distemper seemed to predispose them to infection of the urinary tract.

(3) Moderately prolonged constipation and diarrhœa in dogs was not associated with relative increase of organisms in the mesenteric glands or with a urinary tract infection.

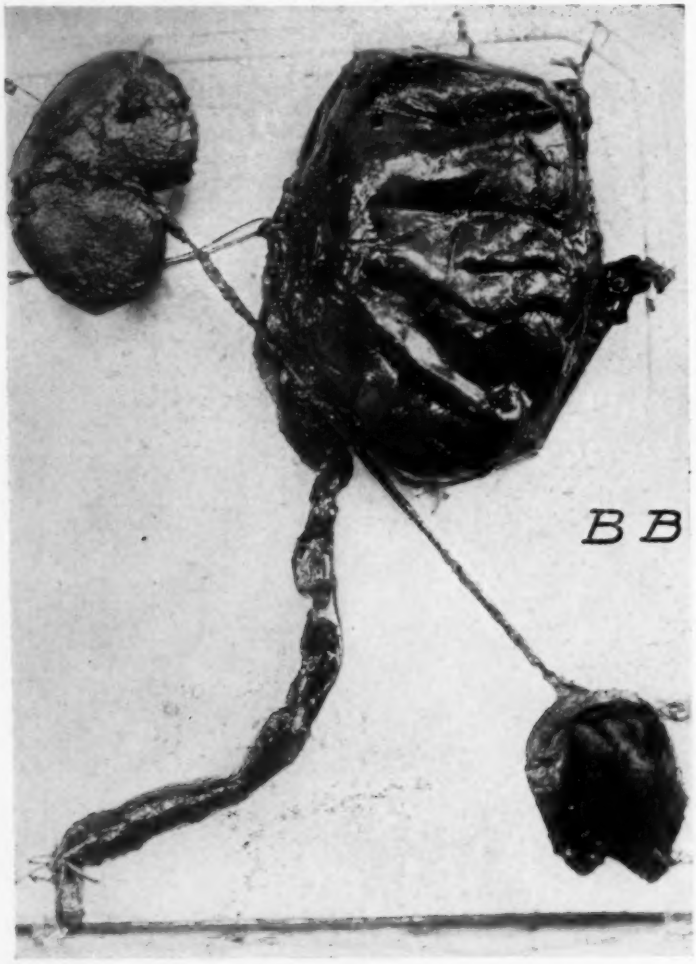

FIG. 7.—Dog BB. Thirty-eight-day hydronephrosis from ligated ureter. Death from respiratory disease. Sterile hydronephrosis.

(4) Obstruction of the large bowel, or traumatism of the bowel is associated with an increased bacterial content of the mesenteric glands and urinary tract infection occurred in two dogs.

(5) No evidence was forthcoming that organisms reaching the mesenteric glands from the bowel tended to involve the urinary stream by way of the lymphatics. It is probable that Franke's hypothesis in this connection would apply only to those instances where a diseased bowel or appendix was in contact with the peritoneum overlying the kidney. This explanation obviously would not include the great majority of kidney infections.

(6) Cultures of live tissue, bile, and hearts blood were uniformly sterile and led one to believe that organisms leaving the normal intestine do so in small numbers and are at the most but transient inhabitants of the blood or liver tissue.

(7) The significance of the passage of intestinal organisms through normal as well as pathological bowel wall to the mesenteric glands cannot be

overlooked. While it is undoubtedly true that these organisms reach the blood stream in but relatively small numbers and inconstantly, it is, nevertheless, possible that increased virulence of the organisms, lowered resistance of the host as well as actual lesions of the bowel wall would greatly increase the number of organisms reaching the blood stream. This conclusion would accord with the clinical relation between gastrointestinal lesions and urinary tract infections.

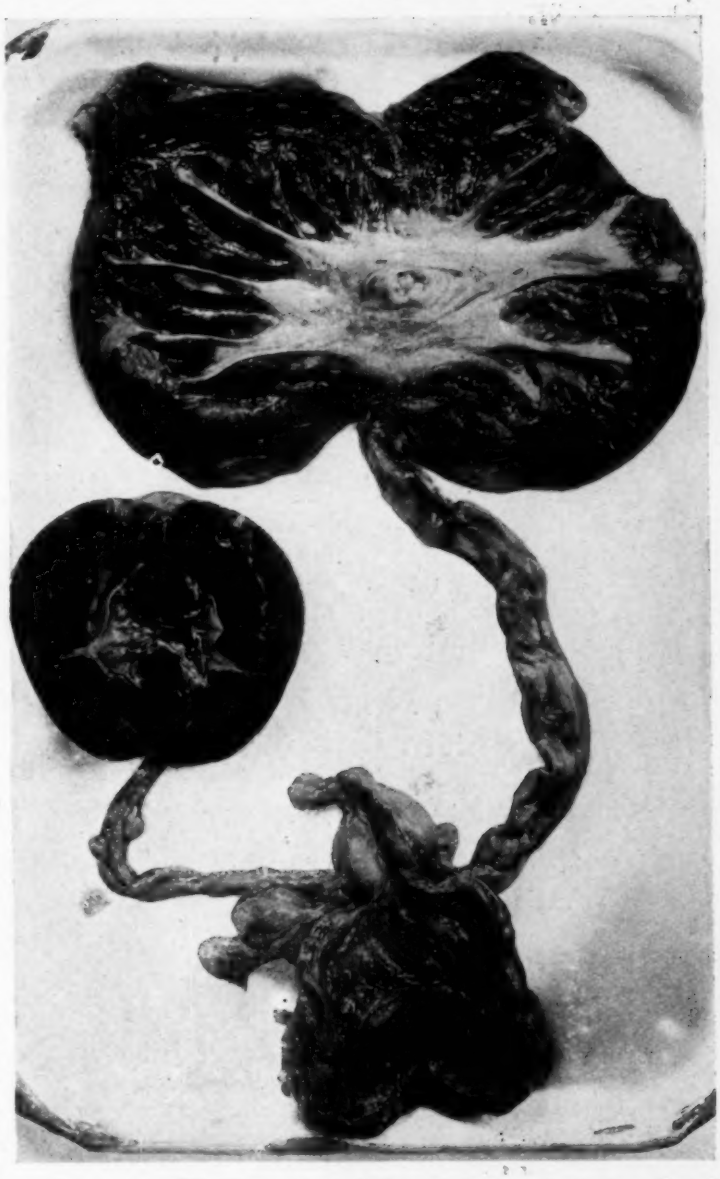

FIG. 8.—Dog EE. Four and one-half-month hydronephrosis from ligated ureter. Intravenous injection of B. coli three months and four months after ligation of ureter did not inject the hydronephrosis.

It is possible, therefore, that a developing hydronephrosis in man may be infected from organisms reaching the blood stream from the bowel.

Blood Stream Infection of Hydronephrosis.—From the foregoing material it becomes apparent that blood stream infections, from whatever source, are the most common means of entry of organisms into a developing hydronephrosis. Many years ago Beidle and Kraus [12] and Brewer [13] demonstrated that organisms

were rapidly secreted into the kidney urine, after their introduction into the blood stream. To convince ourselves that B. coli were thus easily secreted into the kidney urine after injection into the blood stream, two dogs were used. The right ureter was divided and a fine canula placed into its proximal end. Cultures of the right kidney and bladder urine were taken for control. Two cubic centimetres of a B. coli suspension in salt solution were injected into the femoral vein, and cultures were taken every few minutes from the right divided ureter as well as from the bladder urine. After one minute, 4 to 6 drops of right kidney urine grew 17 to 20 colonies of B. coli. A decreasing number of colonies were present from the right kidney urine at intervals of 4 to 35 minutes after the intravenous injection of B. coli. After 35 minutes only one colony was grown. This shows that B. coli in the circulating blood are very rapidly secreted into the kidney urine and that after 35 minutes have practically disappeared from the kidney urine. This is of special interest in establishment of infectious lesions in the urinary tract because without obstruction of the urinary outflow it is probable that the organisms are very rapidly eliminated in the urine and produce no lesions.

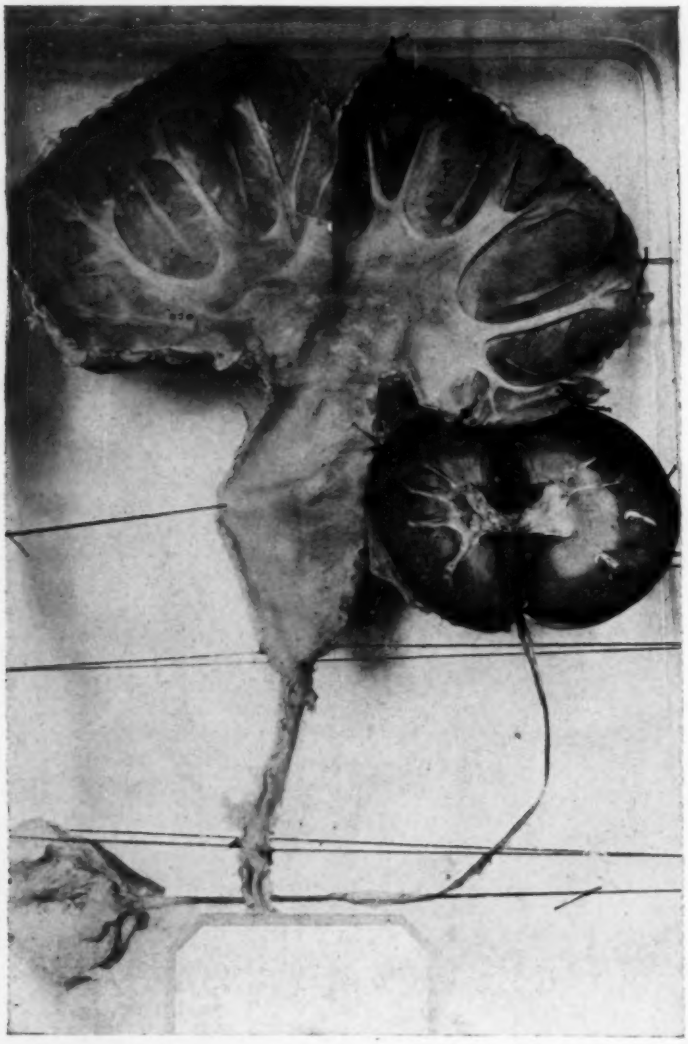

FIG. 9.—Dog GG. Seventeen months sterile hydronephrosis from ligation of ureter. Intravenous injection of B. coli nine months after ligation did not infect the hydronephrosis.

The effect of ligation of the ureter and development of a hydronephrosis on the kidney function has been carefully studied experimentally by Bradford,[14] Keith and Snowden,[15] Keith,[16] Johnson,[17] and others. While the kidney still has some power of secretion at the end of two months, death results if urinary secretion is left entirely to a kidney which has been obstructed for only 19 days (Johnson). Hinman[18] found a kidney obstructed for 26 days did not regain any of its function. With these facts in mind a series of experiments were conducted in 10 dogs to ascertain whether it was possible to infect a hydronephrosis due to complete obstruction of the ureter. In dogs having sterile urine at the time of ligation of the ureter, intravenous injection of 2 c.c. of actively growing B. coli was carried out at intervals varying from one day to nine months after ligation of the ureter. It was found that infection of a hydronephrosis of 1 day, 2 days, 15 days, 20 days, and 60 days' standing was uniformly accomplished by intravenous injection of B. coli. In contrast to these results were the failures to infect hydronephroses of 3 months, 3½ months, 4½ months, 5 months, and 9 months' duration by

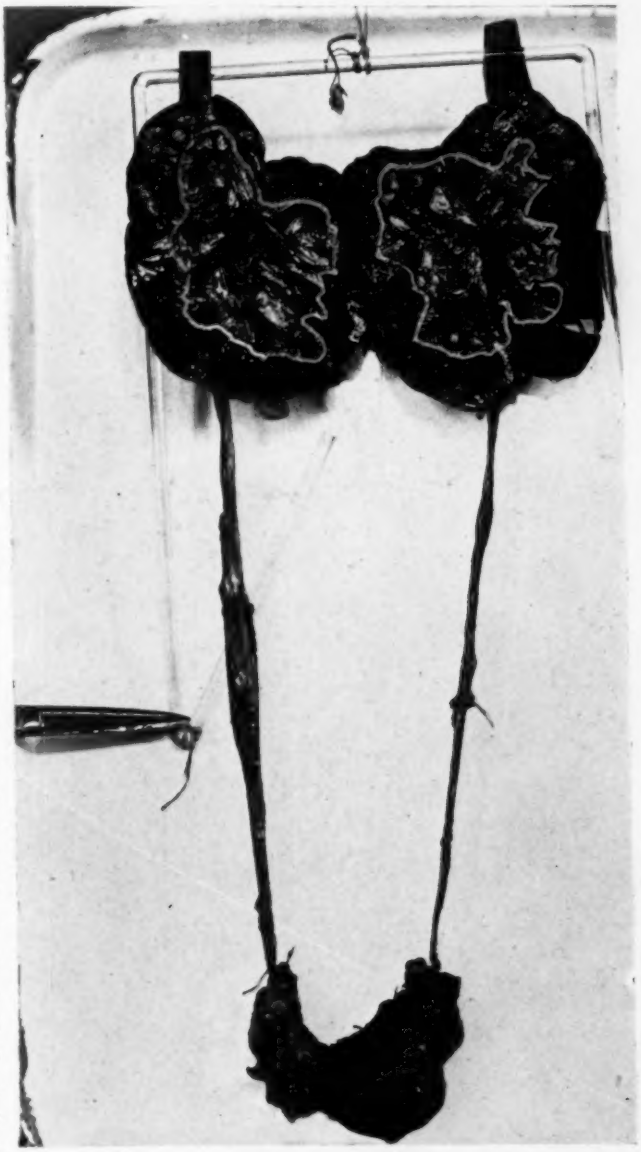

FIG. 10.—Patient died six days after bilateral ligation of the ureters during an operation for carcinoma of the uterus. At post-mortem, both ureters were enormously distended. The right ureter measured 1.25 cm. in diameter and the left ureter 1 cm. in diameter. The walls of the ureter were thin, as though the dilatation had been acute. The renal pelves were markedly dilated and the urine contained in them was under high pressure. Pelvis of kidney outlined.

intravenous injection of B. coli. From these experiments it seems justifiable to conclude that at some time between two and three months after ligation and division of a ureter the resulting hydronephrosis cannot be infected by the way of the blood stream. If by inference these results may be applied to the human, it is obvious that the real danger of infection of complete hydronephrosis is in the first three months of its development.

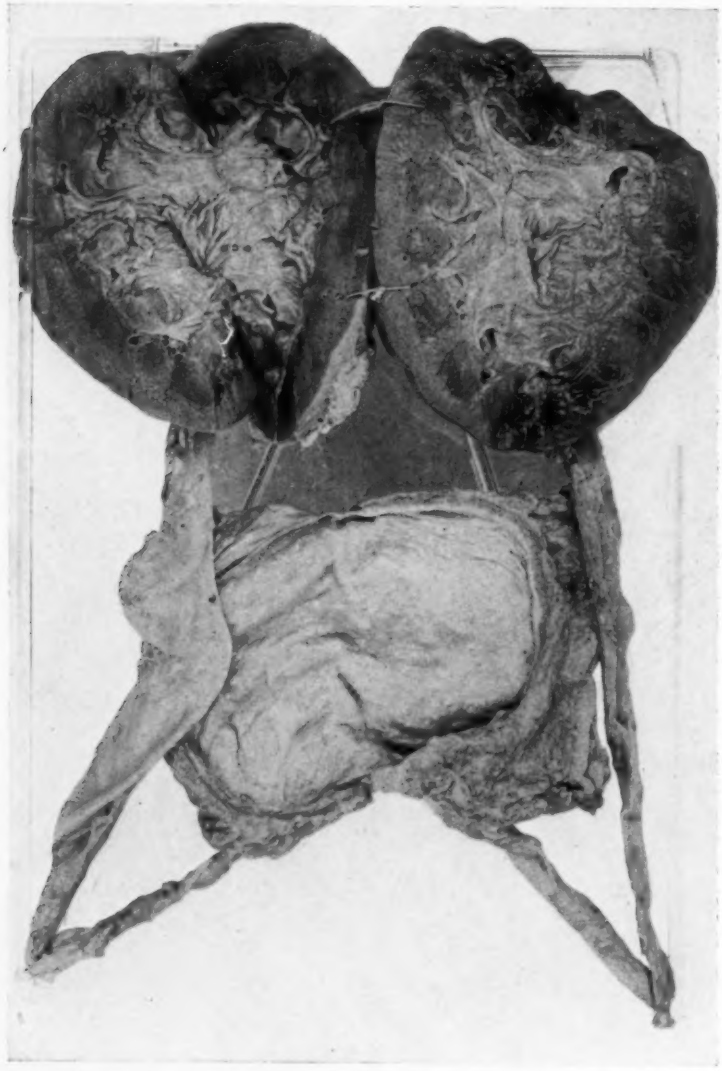

FIG. 11.—Patient died after prolonged labor. Autopsy revealed a bilateral hydronephrosis.

The accompanying illustrations indicate the degree of atrophy of the kidney parenchyma as well as the dilation of the kidney pelvis following ligation of the ureter in the dog. The intrapelvic pressure taken in several of the hydronephroses of over three months' duration gave about 1.5 cm. pressure of mercury. The fluid in the hydronephritic sac was straw colored and slightly cloudy and the data on p. 531 was obtained from examination of the 18 months hydronephrotic fluid.

Compared to the figures for these substances in normal dog urine they are present in very much less quantities, but nevertheless show many of the constituents characteristic of urine.

Appearance	Cloudy
Color	Light amber
Specific gravity	1011
Reaction	Acid
Serum	Albumen (plus, plus)
Casts	0
Cells-blood	0
Leucocytes	Few
Benzidin test for blood	0
Crystaline elements	0
Sugar	Very slight reduction
Urea	Very little in comparison to urine
Uric acid	2.20 mg. per 100 c.c.
Creatinine	14 mg. per 100 c.c.
Total nitrogen	164 mg. per 100 c.c.
Non-protein nitrogen	104 mg. per 100 c.c.

CONCLUSIONS

(1) Closed hydronephroses in dogs may be infected through the blood stream up to three months after the onset of their development.

(2) Closed hydronephroses of more than three months' standing are no longer liable to infect through the blood stream.

(3) Closed hydronephroses are rarely, if ever, infected through the lymphatics leading from the bowel to the kidney. Ascending ureteral lymphatic infection of hydronephroses is possible but improbable.

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THE FATE OF THE FRACTURED CARPAL NAVICULAR*

By Kellogg Speed, M.D.
of Chicago, Ill.

The position of the navicular bone in the carpus is probably one cause of its injury in falls on the hand or similar traumata, such as backfire jerks when cranking an automobile engine. Although the bone lies in and dominates the proximal row of the carpus, its position changes over a wider arc in all wrist movements than any other carpal bone. This bone attempts also to ally itself with the distal row. If falls are sustained on a hand in true adduction, the navicular bears much of the brunt of the forced extension of the wrist and the conveyance of force to the forearm. Navicular fracture with or without dislocation of one or both fragments is a fairly frequent occurrence.

The blood supply of all the carpal bones is rather scant, arising from terminal branches of the radial and ulnar arteries, which spread out in a periosteal branching without the formation of a true nutrient artery. Some blood reaches the bone *via* the ligamentous attachments. The navicular receives its supply from small vessels which enter about the middle of the bone and spread out as indicated in the periosteum to supply both the cartilage and osseous tissue. As the usual site of fracture of this bone is near its middle, because of its peculiar anatomical position, the blood supply is always seriously interfered with immediately inasmuch as these small vessels are torn off by the trauma. Even the ligamentous supply can be cut off by lacerations.

Men sustaining carpal injuries may not present gross deformities, crepitus, or much immediate change in function, so that a large proportion of the fractures are overlooked clinically. It is also true that even when a skiagram is made of the wrist a fracture may not be noticed. There results consequently non-recognition of the fracture of the navicular; advice is given to use the wrist. Baking, forced passive movements and active movements are insisted upon and no fracture diagnosis is made until weeks, months or years later, when the dysfunction becomes so prominent that someone interprets the condition correctly from the symptoms and a skiagram. In some patients not only is the navicular fractured, but one of the fragments, usually the proximal, is dislocated out of position in relation to the radius and the surrounding carpal bones. This fragment dislocation may be accompanied by its companion in the proximal carpal row, the lunate. It is not my purpose to go into the symptomatology, but to attempt a description of the fate of the bone.

The course of the life of the navicular after a fracture may take either of two different paths. Fracture without separation (dislocation) of fragment or with impaction, which is recognized and treated by early and prolonged

* Read before the American Surgical Association, April 18, 1924.

immobilization, may heal satisfactorily without untoward results. This fact has been shown clinically.

The fracture unrecognized or discovered after a time of a week or more, during which motion and use have been advised, pursues a different course. It is with this quite common result that we must deal. After the unrecognized and misused fracture, pain increases for a period of several years. Along with the pain comes diminution of functional use of wrist, hand and forearm, betrayed by lack of hand grip, decreased wrist motions and atrophy of the forearm muscles.

In the navicular bone after complete fracture, excepting isolated fractures of the tuberosity, blood supply is rapidly cut off and the main mass of the bone cells undergoes slow death. Just how long it takes for this death to occur cannot be positively stated; probably it is complete within a week. The navicular then at first retains its original density, and as the weeks and months pass, when pain inhibits use of the other bones of the hand and forearm there is seen a marked contrast between the navicular and neighboring bones, which must lose calcium in the process of atrophy of disuse. This atrophy can be demonstrated even in the forearm bones. Formation of a new blood supply is constantly discouraged by movements of use which overcome the delicate efforts of the small vessels involved. As attempts at use or passive movements are continued, the loss of blood supply of the bone becomes permanent.

A few weeks after injury a skiagram shows the plane of fracture, a navicular uniformly dense and with deeper shadow than the other carpal bones. As time passes, the plane of fracture appears to widen and less difficulty is experienced in making a röntgenologic diagnosis. Eventually the bone appears to undergo absorption in its body. The cartilaginous and cortical edges retain their outline markings for many months, but in three to five years light spots appear in the bone shadow quite remote from and not necessarily connected with the apparent bone absorption going on at the fracture plane. These lighter areas may be puzzling unless one studies the pathology minutely. New bone formation from surrounding bones begins to appear in one to two years, and if an average of five years is taken we may expect to find considerable exostosis formation manifested from the lower articular end of the radius. The degree of this new bone development is probably governed by the amount of forced work attempted by the injured hand. In women who do little manual labor the exostoses are minimal; in adult men the amount of bone thrown out may cloud the lines of the wrist and carpus and appear to be sufficient to cause bony ankylosis.

At operation on the fractured navicular three to five years after the break, when the carpal joint is opened synovial fluid is present. This is not abnormal except that it may be slightly thicker and stained a deeper yellow color than normal. The bone when exposed to view seems eroded, its surface may present pits and the cartilage may be wanting, especially near the fracture plane. On the whole, however, the cartilage retains its color, apparently is

living, and may have its normal smooth or shiny surface. When an attempt is made to remove the bone fragments, they are found to be quite friable and if care is taken to remove them *en masse*, one finds that the bone has become a mere shell of surrounding cartilage and cortex which encloses a yellow fat-like material. This internal portion of the bone is all that remains of the former rather dense cancellous tissue of the body of the navicular. It may easily be scraped and lifted out from the enclosing shell. There is erosion and absorption of bone grossly evident at the plane of fracture, and although only two fragments could be made out in the skiagram, three or more may be found in the specimen. Overlying shreds of old capsular ligament may be adherent to the bone, especially at the tubercle. As a rule the joint capsule has completely healed and is represented by an abnormally thick whitish fibrous material.

Specimens of the untreated fractured navicular removed within six months after the time of injury, show on microscopic examination that the main mass of the cancellous bone tissue is dead. No normally staining nuclei can be found in the bone cells. At the fracture surface two general changes can be noted, one regenerative, the other degenerative. There is a very faint effort at new bone or callus formation. This is really only in microscopic areas. The main change is degenerative. The mass of cancellous tissue near the fracture plane has lost its cellular identity. Extending from the fracture surface is an invasion of small round cells in which are scattered many of the osteoclastic giant multinuclear cells marking a steady progressive absorption of the bone. The cortex and cartilaginous rim usually present a better resistance and around the edges of the bone the section shows cells and nuclei with practically normal staining reaction, evidently still alive. The main mass of the cancellous tissue, however, is dead.

After four or five years the whole interior of the bone is soft and fat-like. On section of this material nothing is found but fibrous tissue, no fat, no trace of bone cells or lamellæ. Around the bone edge the shell is composed of cortical bone with a few rows of bone cells containing nuclei and with fairly healthful cartilage covering where it should be present.

After a study of a series of these fractures at varying periods after the original trauma, I feel justified in saying that the original fracture interference with the blood supply cuts off nutrition to the cancellous structure. Should the condition be recognized and sufficient rest be offered the bone, revascularization with a saving of the bone may result. In the neglected cases bone death rapidly ensues, and the process of malacia or osteoporosis begins, ending in complete absorption of the main mass of the bone. As far as I can determine we must revise our ideas about the influence of the synovial fluid on these fractures. It has formerly been taught that the irritative effect of the synovial fluid led to destruction of the bone, but my sections seem to prove just the opposite, namely that the synovial fluid offers sustenance to the superficial layer of cartilage and cortical bone and maintains the nutrition of the cells for years.

The new bone formation from surrounding bones must be a reaction to the presence of the dead navicular and is protective, that is, it is a natural effort to stiffen the wrist to inhibit motion and consequently relieve the patient from pain.

Using the clinical and pathologic evidence obtained from a series of these injuries, there is no hesitation in advising immediate and prolonged splinting of the fractured and undislocated navicular. If dislocation of fragment has occurred, I believe operative removal is indicated. Certainly in all fractures unrecognized more than a few days operative removal of the whole bone promises the quickest return of function in the hand and wrist. Delay gains nothing.

THE REGENERATION OF THE MENINGES

By Maxwell Lear, M.D.

and

Samuel C. Harvey, M.D.

of New Haven, Conn.

from the section of surgery, yale university school of medcine

THE PIA-ARACHNOID

In a previous paper [1] evidence was presented to show that the dura mater when injured heals rapidly without the formation of adhesions to the subjacent structures. The mechanism of the repair of this membrane is similar to the repair of an injury elsewhere in the body with the exception that the external surface of the arachnoid acts as a limiting membrane beyond which no further reaction takes place and against which the inner lining of the dura is formed. This impregnability of the arachnoid surface to the reaction of repair in the dura prevents the formation of adhesions and acts as a mould for the reconstruction of the dura. Reason was found for suspecting that the cells on the inner surface of the newly formed dura are derived from the polyblasts or fibroblasts of the organizing blood clot, rather than intact dura.

In view of these findings it seemed of interest to investigate the healing of the pia-arachnoid when the site of its injury was covered by normal dura. It was supposed that under these circumstances a similar reaction would take place and that the pia would heal also without adhesions.

Healthy adult dogs were chosen as the subjects of these experiments and the operative procedures carried out with complete surgical asepsis under ether anæsthesia. The skull was opened in the parietal region with a crown trephine and the defect enlarged with the rongeur to a size of about 8 square cm. which was roughly rectangular in shape. A curved dural flap with the convexity upward was turned down, great care being taken not to injure the pia and to protect the inner surface of the dura from any damage. In the first series of these experiments the pia over the cortex, well away from the line of dural incision, was touched with the tip of a spatula which had been brought to a cherry red degree of heat. This immediately produced a coagulation of the pia-arachnoid together with a thin layer of the adjacent cortex. The dural flap was then replaced and carefully sutured with interrupted fine silk sutures. The wound was closed in layers with interrupted silk sutures, care being taken to obtain accurate approximation. In a second series of experiments the same procedure was employed with the exception that the injury to the pia was obtained by plunging the point of a mosquito clamp through it into the cortex and spreading the points apart on with-

drawal, thus producing a small, sharply localized area of injury. The animals were sacrificed by ether at appointed intervals of time, the brain and meninges carefully examined in gross, following which suitable blocks of tissue were hardened in formalin for microscopic study.

The protocols are as follows:

Series I.—Protocol I, Dog No. 12.—Operated upon January 8, 1923 and sacrificed on January 16th, 8 days duration.

Gross Examination.—The dural wound was healed per primam and there were no adhesions present along the line of suture. At the site of the pia-arachnoidal injury the dura was firmly adherent to the damaged pia-arachnoid and forcible stripping resulted in laceration of the underlying cortex.

Microscopic Examination.—Section was made through the area of adhesion noted above. The dural portion of the section shows fibroblastic activity on the outer aspect where the muscle is undergoing a process of healing in conjunction with the endosteal layers. The dura itself is somewhat swollen on its cortical aspect and there is an invasion of young fibroblasts among the fibrous strands composing the first two or three layers of the dura nearest to the injured pia. Beneath this the blood clot is being organized with a great deal of young fibroblastic tissue. This gradually becomes a clear layer of newly forming fibrous tissue overlying cortical debris which on the separation of the adhesions was stripped away. The cortical portion of the section shows nothing of importance except the granular broken down brain tissue to which is attached here and there a fragment of the new fibrous tissue.

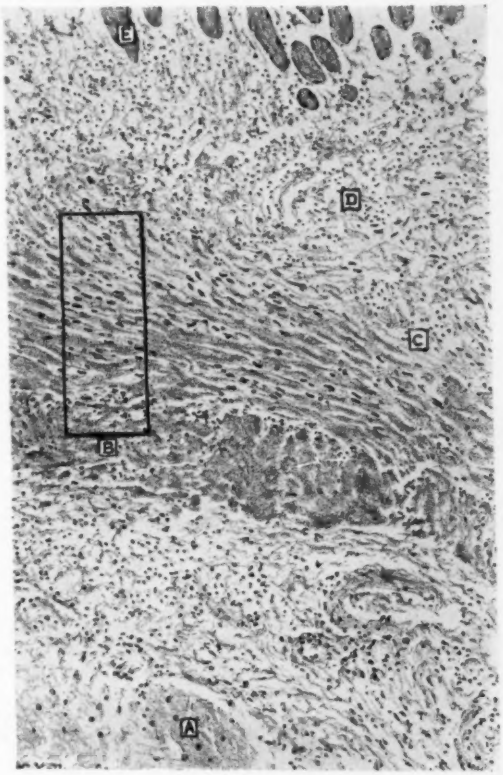

Fig. 1.—Protocol I, 8 days, (low power). A. Damaged cortex. B. Healing near inner surface of dura. C. Endosteal surface of dura. D. Healing between dura and muscle. E. Temporal muscle.

Protocol II, Dog No. 6.—Operated upon September 12, 1922 and sacrificed on October 3, 1922, 11 days duration.

Gross Description.—The dural wound was healed per primam. Upon attempting to separate the dura from the underlying cortex there were found adhesions at each point of suture between it and the pia-arachnoid, but there were none in the spaces between the sutures. The dura was very tightly adherent to the damaged pia-arachnoid but peeled away fairly readily leaving a slightly discolored velvety area at the centre of the zone of brain injury.

Microscopic Examination.—The cortex is broken down and shows on its meningeal surface an active healing process which includes some new vessels with fairly well developed walls. Round cells and polyblasts in various stages of activity prevail through-

out the field with here and there a large flat cell with a single nucleus. The large cells are found throughout the regenerating area and are undoubtedly macrophages.

PROTOCOL III, Dog No. 5.—Operated upon September 20, 1922 and sacrificed on October 4, 1922, duration 14 days.

Gross Description.—The dural wound had healed per primam. Adhesions were present at two suture points but the remaining seven suture points were not adherent to the subjacent pia. The dura stripped away readily from the underlying structures but carried with it a fine granular surface intimately connected with the underlying brain. The cortical surface was somewhat rough and had a velvety appearance but showed no distinct gross injury.

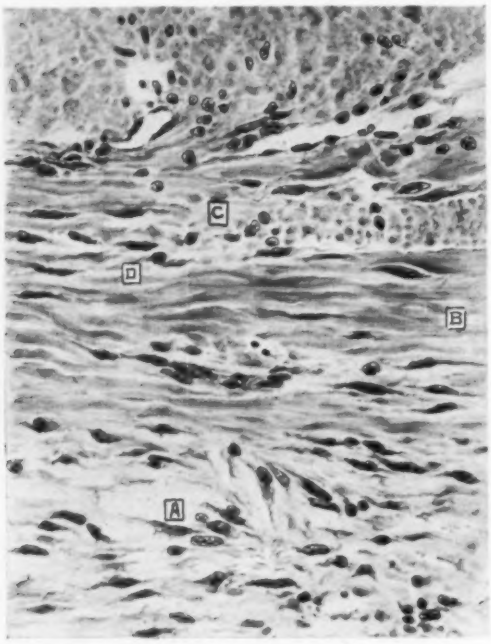

FIG. 1a.—Protocol I, 8 days, (high power). A. Endosteal layer of dura. B. Undamaged dura. C. Healing of damaged area below normal dura, showing invasion of dura by the healing process at D.

Microscopic Examination.—The section through the area mentioned above included the dura and the healing area of the damaged pia-arachnoid and cortex. The dural portion shows normal, intact dura but arising from it on the pial aspect there are numerous fibroblasts and some more mature fibrous connective tissue. On the cortical side there is a definite polyblastic activity with a deep layer of fibrous tissue. The entire healing process involves the dura, pia and arachnoid and merges them all into one compact layer which, on separation in gross, was pulled away from the cortex, carrying some of it with the dural portion.

PROTOCOL IV, Dog No. 4.—Operated upon September 26, 1922, and sacrificed on October 12, 1922, duration 16 days.

Gross Description.—The dural wound had healed per primam. There was an adhesion at one suture point but the remainder of the sutures were free from the pia-arachnoidal surface. The dural surface when peeled away from the cortex was smooth except at the site of the cortical injury where a granular mass was adherent to the dura. The brain surface seemed clean and was not definitely lacerated but had a somewhat velvety appearance. There was no evidence of gross adhesions between the dura and the pia.

Microscopic Examination.—This section, like the preceding one, shows a well formed compact dura. The portion of the membrane directly overlying the damaged cortex is adherent to the healing process beneath it. The form of the adhesion is that of a continuity of structure of the normal dura and the fibrous tissue which is being laid down over the damaged cortex to replace the injured pia-arachnoid. As in the preceding section there is no point of difference between the dura, pia and arachnoid, the whole forming one homogeneous layer of fibrous tissue which has peeled away from the subjacent cortex, carrying a portion of it along.

PROTOCOL V, Dog No. 3.—Operated upon September 15, 1922 and sacrificed on October 3, 1922, duration 18 days.

Gross Examination.—The dural wound had healed very well, with one point of suture adherent to the cortex, the others being free. In the centre of the dural flap and overlying

the site of the pia-arachnoidal injury there was a dark brown mass about 1 x 1 cm. which on section appeared to be covered by a fine glistening layer of tissue continuous with the inner surface of the dura. There was a depression on the cortex underlying this mass corresponding in area and in position to the mass on the dura. The cortex itself was velvety in appearance.

Microscopic Examination.—The dural portion of the specimen shows an interesting and important condition. The mass described in the gross examination appears to be covered by a definite limiting membrane. Continuous with the dura and beneath it is a blood clot undergoing progressive fibrosis. The layer which is described above as lying beneath the clot is also composed of fibrous connective tissue and resembles the adjacent dura, joining with it at either side of the mass. The cortex is broken down and filled with residual blood pigment and cortical debris. There is some early fibrosis. The blood-vessels show well-defined walls. There is little evidence of any pia-arachnoid tissue on the cortical portion of the section, the regenerating membrane having been stripped away with the dura.

FIG. 2.—Protocol IV, sixteen days, (low power). A. Temporal muscle. B. Dura adherent to damaged cortex. C. Cortex.

PROTOCOL VI, Dog No. 7.—Operated upon October 24, 1922 and sacrificed on November 14, 1922, duration 21 days.

Gross Examination.—The dura separated readily from the cortex and was glistening in appearance except at the area overlying the cortical damage where a portion of the cortex was adherent to the dura. The injured cortical surface had the same velvety appearance as noted previously.

Microscopic Examination.—The muscle and the dura are practically normal in appearance The dura is fibrous and shows on its inner aspect numerous young fibroblasts, an occasional red cell and rarely a macrophagic cell as described in previous examinations. The cortical surface is irregular and not covered by anything resembling pia-arachnoid, the healed membrane having stripped away with the dura and forming a portion of it.

PROTOCOL VII, Dog No. 8.—Operated upon November 10, 1922 and sacrificed on December 8, 1922, duration 28 days.

Gross Examination.—The dura was well healed along the line of suture and showed no adhesions at any suture point. There was no gross evidence of adhesions between the dura and the cortex. The damaged area of the brain had a velvety appearance and was overlaid by one fairly large vessel. There was no gross evidence of cortical substance adhering to the dura.

Microscopic Examination.—This section shows a condition similar to that in the

previous examination, but more advanced. What seemed to have been dura stripping away from the cortex is actually one layer of tissue including normal dura which is lined by a thin membrane of young fibrous tissue of varying thickness resembling the arachnoid and below this layer some of the cortex. The process of the healing of the cortex, pia-arachnoid and dura into one cicatrix is complete.

PROTOCOL VIII, Dog No. 10.—Operated upon on January 8, 1923 and sacrificed February 15, 1923, duration 38 days.

Gross Description.—The dura easily stripped from the underlying structures but was covered with a brownish mass of tissue which was recently organized blood clot. Sutures were everywhere healed over on the inner surface of the dura and were covered in by glistening membrane. The cortex showed a general ecchymosis and was swollen and granular in appearance. The general picture was that of the healing of a recent injury rather than of one produced at the time of the operation.

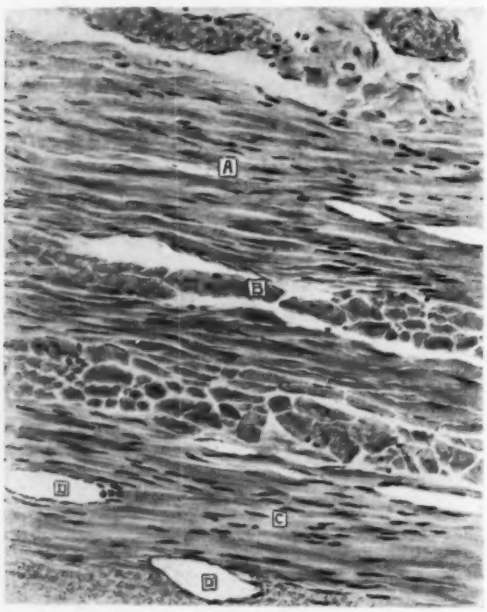

FIG. 3.—Protocol IV, sixteen days, (high power). A. Normal dura covering site of injured pia-arachnoid. B. Point of continuity of healing between dura and new pia. C. Layer of fibrous tissue which has replaced damaged pia-arachnoid. D and D¹. New blood-vessels lying beneath layer C.

Microscopic Examination.—The dura shows a thick layer of fibrous tissue which on its cortical aspects gives evidence of a recent healing process with free blood cells, round cells and fine granulation tissue. The picture is probably due to a fairly recent trauma. On the cortical surface the brain is free of pia-arachnoid except where the membrane was undamaged or out of the experimental field. One portion of the dural section shows the dura joined to adjacent granulation tissue and some broken down cortical substance. This portion corresponds to the defect in the brain caused by stripping the dura away from it.

Series II.—PROTOCOL I, Dog No. 260.—Operated upon July 20th, sacrificed on August 28th, duration 39 days.

Procedure.—Decompression left side, dural flap turned down and then stitched back into position. No damage done to pia-arachnoid.

Gross Examination.—No adhesions. The dura was everywhere completely healed. Sutures show plainly through the lining of the dura and at one point where the edges have retracted new dura had been formed completely filling in the defect.

Microscopic Examination.—The pia-arachnoid underlying this area shows no evidence of damage, and no adhesions.

PROTOCOL II, Dog No. 2114.—Operated upon July 19, 1923 and sacrificed August 28th, duration 40 days.

Procedure.—Large decompression flap turned down and the dura reflected downward without any injury to the pia. At the lower edge of the area exposed beneath normal dura a mosquito clamp was struck through into the brain and spread so as to cause a defect in the pia-arachnoid. The dura was sutured back into position with interrupted silk. A small amount of blood clot was left beneath the dura.

Gross Examination.—Adherent only at the point of puncture. Here on separation

small fragments of cortex were torn out and came away with the dura. Healing has taken place in the region of the stitches without adhesions.

Microscopic Examination.—There is a scar in the cortex completely healed where the mosquito clamp entered. At the surface in this region the pia-arachnoid has disappeared and the dura is apparently directly continuous with the scar.

PROTOCOL III, Dog No. 6.—Operated upon July 25, 1923 and sacrificed August 28, 1923 duration 34 days.

Procedure.—The same procedure was carried out as in the previous experiment with the exception that the dura was not stitched into position but simply laid back over the defect in the pia-arachnoid.

Gross Examination.—The dura is retracted about ½ cm. but this area is healed over with only a few very fine and cobwebby delicate adhesions. The site of the injury was completely covered by what had been normal dura. On pulling it away from the cortex, however, it brings with it cortical tissue, leaving a defect at the point where the original injury was made.

Microscopic Examination.—Not made.

PROTOCOL IV, Dog No. 3120.—Operated upon July 26, 1923 and sacrificed August 25th, duration 30 days.

Exactly the same procedure was carried out as in the previous experiment.

Gross Examination.—On separation of the dura from the cortex there are two dense adhesions, one at the upper angle of the dural flap at a point where the pia came in contact with an uncovered bone spicula and undoubtedly was injured. The second adhesion was to the dura at the point where the clamp had penetrated. Elsewhere the retracted dura had healed without adhesions.

Microscopic Examination.—Not made.

DISCUSSION

As a result of these experiments it has been found that where there is an injury to the pia-arachnoid and cortex, even though the overlying dura is uninjured, dense adhesions between all three layers of the meninges and the cortex are formed. As early as eight days following the injury, the dura is sufficiently adherent to tear away with it portions of the underlying cortex. The longer the period of healing, the greater the density of the adhesions and even after five weeks there is no attempt at solution of the adhesions. One may feel certain then that injuries to the pia-arachnoid and underlying cortex lead to the formation of adhesions with the overlying normal dura, and that these adhesions persist.

Microscopically, at seven days post-operative, the dura is swollen and shows an invasion of fibroblastic and polyblastic cells which are passing inward toward the area of damage to the pia-arachnoid and cortex, where they meet similar elements engaged in the repair of these structures. In other words, the resolution of the injury takes place not only in the damaged membranes, but also in the overlying undamaged dura. As time goes on, the dura and the area of injury become organized into one fibrous structure, thus resulting in a firm adhesion of a strength sufficient to tear the underlying cortex on attempts at forcible separation.

One cannot help but suspect that in some fashion the dura involved has received some unrecognized injury and particular care was taken in the second series to avoid any possibility of this. The dura was opened and the

surface which was to lie over the injured point in the arachnoid was not touched even with saline and the damage to the pia-arachnoid and cortex was made by thrusting in a clamp and spreading the jaws on withdrawing it. It is certain then that the area of dura reacting to the pia-arachnoid injury was not in any extent itself damaged.

The second possibility that suggested itself was that the presence of blood alone might induce a reaction on the part of the dura. An experiment was tried in which the pia was not injured, but the dura opened and closed in exactly the same fashion as in the other experiments. A small amount of blood was left between it and the arachnoid but no adhesions resulted. This might have been expected from the fact that the dura will fill a defect in itself without forming adhesions to subjacent structures (by means of the resolution of the blood clot filling the defect). Whether or not the presence of blood induces any inflammatory reaction in the dura is not determined, and will be the subject of further investigation. In the presence of an intact arachnoid it does not produce adhesions.

It is known then, that a necessary premise to the formation of adhesions between the dura and the pia-arachnoid is injury to the latter. The injury in these experiments included damage not only to the pia-arachnoid, but to the cortex also. Might an injury thus extensive be necessary in order to obtain such a result? We think not, for in certain instances there were adhesions about the sutures placed in the dura. The injury here was undoubtedly caused only by the abrasion of the arachnoid by the suture itself, as extreme care was taken in the placing of it. Such an abrasion could scarcely do more than damage the lining cells of the arachnoid; certainly not the cortex, probably not the pia. It is felt then that the essential point in the formation of the adhesions found in these experiments is the injury to the outer cells of the arachnoid. In certain areas of the meninges where the arachnoid and pia are widely separated, as in the basilar cisternæ and over the cord, such injury would probably not involve the pia, which might well act then as another limiting membrane. However, over the cortex the septa are so numerous, and the lacunæ so shallow, that any reparative process in the arachnoid will probably stimulate a similar reaction in the pia, and if sufficiently severe, in the cortex itself. The essential factor is, then, the damage to the superficial layer of the arachnoid.

It is of interest to consider the reasons why the arachnoid and the dura react in such a different fashion when healing. It had been noted previously that the cells, which in the healing dura come to form the inner layer, are apparently derived from either polyblastic or fibroblastic cells originating in the adjacent tissue and not derived from an ingrowth of the cells lining the normal dura. They meet at the arachnoid surface an impenetrable barrier. On the contrary, the cells concerned in the organization of the injured arachnoid do not meet such a barrier on reaching the overlying dura, but pass directly into it, and the dura takes part in the inflammatory reaction. For two reasons then, the one that the lining cells of the newly constructed dura

are probably derived from granulation tissue, the other that the lining cells of the normal dura do not prove impervious to the cells of the adjacent reparative action in the pia-arachnoid, it may be strongly suspected that the dura is not lined with true endothelium, but rather by cells which have undergone a certain metaplasia, from meso-blastic elements, in order to serve the same purpose.

Support for this opinion is derived from the experiments of W. C. Clarke,[2] who found that mesothelium could be formed from mesenchyme, even in adult life. Lewis[3] states: "It seems probable that endothelium is a real differentiation from the primative mesoderm, while mesothelium is more in the nature of a transformation in the form of the cells, due to environment." He has observed in tissue cultures the actual transformation of mesenchymal cells into the flat mesothelial forms. He interprets these observations, together with those of W. C. Clarke, as indicating that: "In the healing of wounds of the mesothelium lining the peritoneal, pleural and serous cavities, new mesothelium may arise from the subjacent mesenchyme by the change in form of its cells, and that the repair after abrasion of the mesothelium is not necessarily brought about by a spreading of the adjacent mesothelium over the wound, such as occurs in repair of skin wounds."

If transition so readily takes place in this direction, then one might well surmise that the reverse would occur with equal ease; that mesothelium might revert to mesenchymal cells under the stimulus of an inflammatory reaction. This probably takes place in the peritoneum, the pleura, and the pericardium, whose adjacent surfaces become adherent on the slightest provocation. That such adhesions do not take place when dura regenerates over the injured pia-arachnoid, is evidence that the latter is lined by a more highly differentiated form of cell. When the integrity of this is impaired, the dura mesothelium enters into the repair of the injury and the two membranes become adherent.

The clinical application of these findings is of interest, but largely speculatively so. It is understandable, that in order to have adhesions, there may not necessarily be any injury to the dura, or in other words, that damage to the lining cells of the pia-arachnoid will result in adhesions. It is apparent that this injury may be exceedingly slight and the frequent finding of adhesions at operation and at necropsy is therefore not surprising. Minimal birth injuries, mild attacks of encephalitis and of the so-called serous meningitis, and even the meningeal reactions that occur at the onset of many infectious diseases, may of themselves be sufficient to cause enough damage to the pia-arachnoid to lead to adhesions which later in life may be of clinical importance.

SUMMARY

The lining cells of the pia-arachnoid are more highly differentiated than those of the dura and therefore are more stable in character. The lining cells of the dura are mesothelium derived from the mesenchyme, are less stable and readily enter into any adjacent inflammatory reaction. When

destroyed they are replaced by the transposition of mesenchymal elements into mesothelium.

The inner surface of the dura does not act as a limiting membrane in the presence of an attempted repair in the underlying meninges, but on the contrary enters intimately into the process. Consequently the pia-arachnoid when injured becomes adherent to the dura, and heals with adhesions.

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THE TOXICITY AND RATE OF EXCRETION OF CALCIUM CHLORID FROM THE BLOOD STREAM

By John P. Bowler, M.D.
Fellow in Surgery, The Mayo Foundation
and
Waltman Walters, M.D.
Section on Surgery, Mayo Clinic
of Rochester, Minn.

During the last two years patients in the Mayo Clinic who had obstructive jaundice have been given pre-operative injections of 5 c.c. of a 10 per cent. calcium chlorid solution daily for three days prior to operation in order to lower a prolonged blood coagulation time, and thus diminish the possibility of post-operative hemorrhage. Such procedure has justified itself in the results on jaundiced patients, as reported by Judd and Lyons.

In the therapeutic use of any substance its toxicity is of prime importance, particularly when the medicament is to be given intravenously. In the surgical management of certain of the patients with obstructive jaundice the question has arisen of just how much calcium can be given safely intravenously, and over how long a period. This led us to undertake the study of the toxicity and excretion of calcium chlorid when injected intravenously in normal and jaundiced dogs. Joseph and Meltzer have found 444 mg. for each kilogram of body weight to be the lethal dose of calcium chlorid injected intravenously in a solution in which the crystalline salt is in molecular solution, so that 4 c.c. contain 0.444 gm. They injected this solution at the rate of 1 c.c. a minute. In general our results show a lower lethal dose than that reported by Joseph and Meltzer. Carrying out a technic of constant injection at the rate of 1 c.c. a minute of a 10 per cent. aqueous solution of calcium chlorid, we found the average lethal dose in normal dogs to be 256.4 mg. for each kilogram of body weight, and in jaundiced dogs 386.6 mg. for each kilogram of body weight (Fig. 1).

There is no doubt that the lethal dose of calcium chlorid varies with the rate of its intravenous injection in both the normal and the jaundiced dog, and consequently its toxicity increases as the speed of the injection is increased. In one of our animals 154 mg. for each kilogram of body weight, when injected in five seconds, was sufficient to produce death. This again emphasizes the necessity of injecting solutions slowly intravenously. It is of interest that it required twice the amount of calcium chlorid intravenously to raise the blood serum calcium content * of the jaundiced dog to the same level as that of the normal dog, in spite of the fact that the blood calcium content is practically the same in the jaundiced and normal dogs before and after the

* We are indebted to Miss Helen Ross of the laboratory staff for the quantitative estimations of blood calcium in these experiments.

injection of a lethal dose; this suggests a calcium deficiency in the jaundiced animals which is not otherwise apparent.

The rate of excretion of calcium chlorid from the blood stream after its intravenous injection in various amounts in normal and jaundiced dogs, when injected in 10 per cent. solution, is dependent on the amount of solution injected. Following small doses of calcium chlorid, such as the therapeutic dose (8.25 mg. for each kilogram of body weight) it was observed that elimination from the blood stream occurred in from one-half to one hour (Fig. 2). From five to six minutes after the injection, the blood serum calcium content in the normal unjaundiced dog was elevated from 1 to 2.5 mg. for each 100 c.c. After the same interval, the elevation in jaundiced dogs was from 0 to 1 mg. (Fig. 2). Following the injection of larger doses, such as ten times the therapeutic dose (82.5 mg. for each kilogram of body weight) complete elimination from the blood stream occurs within four hours. Five minutes after such an injection the blood serum calcium content in normal dogs is elevated 14 mg. for each 100 c.c. and in jaundiced dogs, 7.2 mg. (Fig. 3). The latter observation lends itself to conjecture concerning the ultimate fate of calcium injected into an animal with obstructive jaundice.

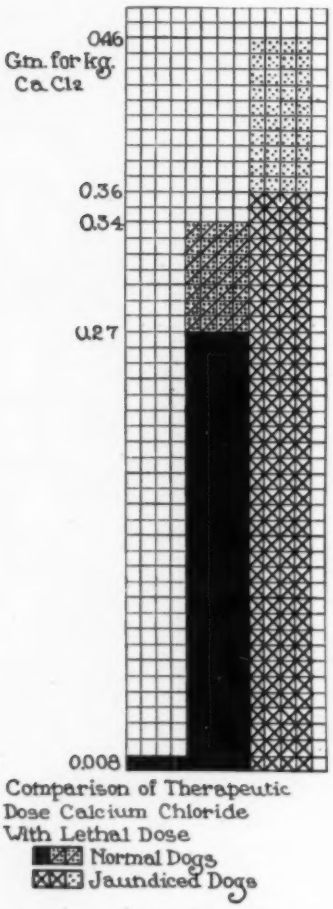

FIG. 1.—Comparison of therapeutic dose of calcium chlorid with lethal dose.

RATE OF EXCRETION OF A THERAPEUTIC DOSE OF CALCIUM CHLORID GIVEN INTRAVENOUSLY IN NORMAL AND IN JAUNDICED DOGS

Dog 2B. Normal.—Body weight 10.7 kg. The therapeutic dose was 8.25 mg. for each kilogram of body weight, making a total of 0.88 c.c. of 10 per cent. solution.

May 8, 1923, 0.88 c.c. of a 10 per cent. solution of calcium chlorid was injected. Normal blood serum calcium was 8.0 mg. for each 100 c.c.; ten minutes after injection it was 9.2 mg.; thirty minutes after, 8.6 mg.; forty-five minutes after, 8.4 mg.; one hour after, 8.6 mg, and two hours after, 8.8 mg.

May 10, 1923, 0.88 c.c. of a 10 per cent. solution of calcium chlorid was injected. Normal blood serum calcium was 11.5 mg. for each 100 c.c.; ten minutes after injection it was 14 mg.; fifteen minutes after 13.3 mg.; thirty minutes after, 12.7 mg.; one hour after, 11.9 mg.; and two hours after, 11.3 mg.

Dog G261. Jaundiced.—May 2, 1923, under ether anæsthesia and employing sterile technic, a median line incision was made, and the common duct brought up and exposed

for a distance of 1 cm. The duct was ligated distally and proximally, and about 8 mm. of duct between the ligatures removed.

May 15, the dog was severely jaundiced. The body weight was 8 kg.; the therapeutic dose was 0.66 c.c. of 10 per cent. calcium chlorid. The blood serum calcium before injection was 10.1 mg. for each 100 c.c.; 0.66 c.c. of a 10 per cent. solution of calcium chlorid was injected. Six minutes after injection it was 11.7 mg.; fifteen minutes after, 12.8 mg.; thirty minutes after, 10.1 mg.; one hour after, 9.7 mg., and two hours after, 10.1 mg.

May 16, 0.66 c.c. of a 10 per cent. solution of calcium chlorid was injected. Blood serum calcium before injection was 9.4 mg. for each 100 c.c. Five minutes after injection it was 10.4 mg.; fifteen minutes after, 9.9 mg.; thirty minutes after, 10.3 mg.; one hour after, 10.5 mg., and two hours after 10 mg.

Dog G166. Jaundiced.—March 20, 1923, under ether anæsthesia and employing sterile technic, a median line incision was made, and the common bile duct brought up and

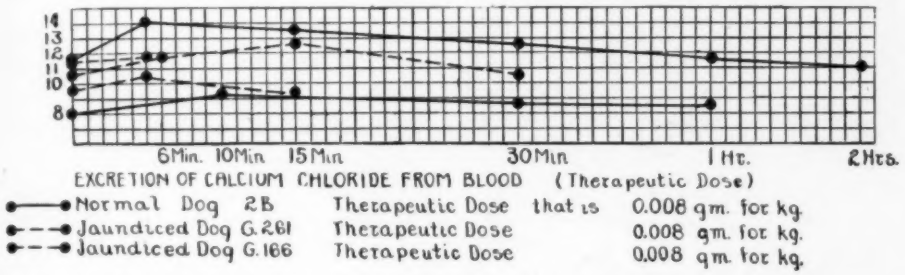

FIG. 2.—Chart showing the curve of excretion from the blood of therapeutic doses of intravenous calcium chlorid.

doubly ligated; a section of about 1 cm. was removed. April 20, an unsuccessful attempt at reconstruction of the bile duct had been made.

May 19, 1923, the dog was severely jaundiced. The body weight was 7.8 kg.; the therapeutic dose was 0.65 c.c. of 10 per cent. solution of calcium chlorid. The blood serum calcium before injection was 11.2 mg. for each 100 c.c.; 0.65 c.c. of a 10 per cent. solution of calcium chlorid was injected. Five minutes after injection it was 11.2 mg.; fifteen minutes after, 11.4 mg.; thirty minutes after, 9.9 mg.; one hour after, 9.9 mg., and two hours after, 10.4 mg.

RATE OF EXCRETION OF TEN TIMES THE THERAPEUTIC DOSE OF CALCIUM CHLORID GIVEN INTRAVENOUSLY IN NORMAL AND IN JAUNDICED DOGS

Dog G267. Normal.—The body weight was 7.5 kg.; the therapeutic dose was 0.6 c.c. of a 10 per cent. solution. (This animal, for nine days previous to this date, had been given increasing multiples of the therapeutic dose, beginning with the therapeutic dose for this body weight of 0.6 c.c. and receiving 5.4 c.c. May 3, 1923.)

May 4, 1923, 6 c.c. of a 10 per cent. solution of calcium chlorid was injected. The blood serum calcium before injection was 12.3 mg. for each 100 c.c. Six minutes after injection it was 26.3 mg.; ten minutes after, 25.8 mg.; fifteen minutes after, 25.2 mg.; thirty minutes after, 22.4 mg.; forty-five minutes after, 19.8 mg.; one hour after, 21 mg.; two hours after, 11.3 mg., and twenty-four hours after, 9.6 mg.

May 7, 6 c.c of a 10 per cent. solution of calcium chlorid was injected. The blood serum calcium before injection was 12.7 mg. for each 100 c.c. Five minutes after the injection it was 26.8 mg.; fifteen minutes after, 22.7 mg.; thirty minutes after, 22.1 mg.; one hour after, 19.6 mg.; two hours after, 16.6 mg.; three hours after, 15.3 mg.; four hours after, 13.4 mg. and five and one-half hours after, 11.5 mg.

Dog G166. Jaundiced.—March 20, 1923, under ether anæsthesia and employing sterile technic, a median line incision was made and the common bile duct brought up and doubly ligated; a section of about 1 cm. was removed. April 20, an unsuccessful attempt at reconstruction of the bile duct had been made.

May 17, 1923, the dog was severely jaundiced. The body weight was 7.8 kg. Six and five-tenths cubic centimetres of a 10 per cent. solution of calcium chlorid was injected intravenously. The blood serum calcium before injections was 10.5 mg. for each 100 c.c. Five minutes after injection it was 17.7 mg.; fifteen minutes after, 15.6 mg.; two hours after, 12.7 mg.; three hours after, 11.2 mg., and four hours after, 10.7 mg.

THE LETHAL DOSE OF CALCIUM CHLORID (AQUEOUS 10 PER CENT. SOLUTION) INJECTED INTRAVENOUSLY INTO NORMAL AND JAUNDICED DOGS AT THE RATE OF 1 C.C. A MINUTE

Dog G267. Normal.—The body weight was 6.8 kg. May 7, 1923, under local anæsthesia and employing sterile technic, the right femoral vein was exposed and

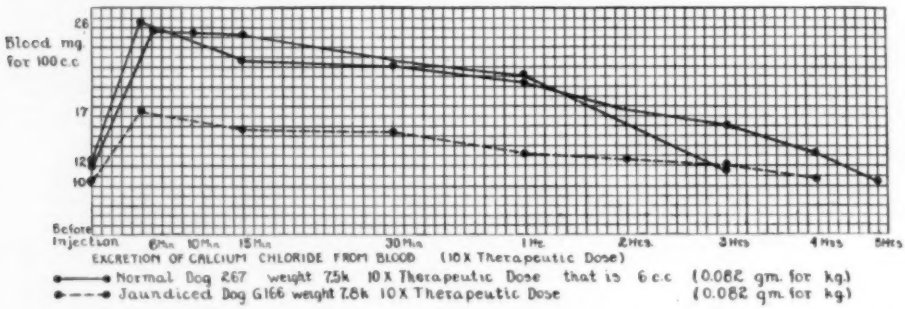

FIG. 3.—Chart showing the curve of excretion from the blood of ten times the therapeutic doses of intravenous calcium chlorid.

brought up, a cannula was inserted, connected with a burette containing 10 per cent. calcium chlorid under constant pressure. The solution was allowed to run at a rate of 1 c.c. a minute. When 13 c.c. had been injected the respirations were slower and deeper. When 15.3 c.c. were injected, the animal was seized with tonic convulsions and expired.

The dog received 15.3 c.c. of a 10 per cent. solution, or 1530 mg. calcium chlorid, which was equal to 225 mg. for each kilogram of body weight, an amount equal to 27.21 times the therapeutic dose. The blood serum calcium before injection was 11.5 mg. for each 100 c.c., and at death it was 36.5 mg.

Dog 2B. Normal.—The body weight was 10.7 kg. May 11, 1923, calcium chlorid was injected, using the same technic as in the previous experiment. When 4.5 c.c. were injected the animal was licking its mouth, swallowing rapidly, and respiration was increased. After receiving 5.5 c.c. the animal vomited; after 9.5 c.c. the rate of respiration was increased; after 11 c.c. the muscular tone was increased, after 13.5 c.c. respiration was markedly increased; after 15 c.c. there were spasms of the diaphragm; after 24.5 c.c. there were violent expiratory efforts, and when the animal had received 30.8 c.c. it had a generalized tonic convulsion and expired.

The dog received 30.8 c.c. of a 10 per cent. solution, or 3080 mg. of calcium chlorid, which was equal to 287.85 mg. for each kilogram of body weight, an amount equal to 34.89 times the therapeutic dose. The blood serum calcium before injection was 10.3 mg. for each 100 c.c., and at death it was 42.9 mg.

Dog G261. Jaundiced.—The body weight was 7.5 kg. May 2, 1923, under ether anæsthesia and employing sterile technic, a median line incision was made, and the

common duct brought up and exposed for a distance of 1 cm. It was ligated distally and proximally, and about 8 mm. of duct between the ligatures removed.

May 18, calcium chlorid was injected by the same technic as in the previous experiments. When 7 c.c. was injected the dog was licking its mouth. After receiving 10.5 c.c. the animal vomited; after 15 c.c. there was prolonged expiration with questionable stridor; after 16 c.c., grunting respiration; after 17 c.c. there was a marked effort at swallowing; after 19 c.c., generalized tonic convulsion; after 21 c.c., grunting expiration, and after 22.8 c.c. the animal expired.

The dog received 22.8 c.c. of a 10 per cent. solution, or 2280 mg. of calcium chlorid, which was equal to 304 mg. for each kilogram of body weight, an amount equal to 36.8 times the therapeutic dose. The blood serum calcium before injection was 10.3 mg. for each 100 c.c., and at death it was 26.9 mg.

Dog G166. Jaundiced.—The body weight was 7.8 kg. March 20, 1923, under ether anæsthesia and employing sterile technic, a median line incision was made, and the common bile duct brought up and doubly ligated; a section of about 1 cm. was removed. April 20, an unsuccessful attempt at reconstruction of the bile duct had been made.

May 21, the dog was severely jaundiced. Calcium chlorid was injected using the same technic as before. A median line incision was made in the neck, and both vagi were sectioned six hours previous to starting the injection; 1/1500 gr. of atropin was given fifteen minutes before the injection and repeated ten minutes later. When 7 c.c. was injected the animal developed clonic muscular spasm. After receiving 17 c.c., there was increased restlessness, and general behavior as to increased muscular activity as above; after 36 c.c. the animal expired.

The dog received 36 c.c. of 10 per cent. solution, or 3600 mg. calcium chlorid, which was equal to 469.23 mg. for each kilogram of body weight, an amount equal to 56.8 times the therapeutic dose. The blood serum calcium before injection was 10.9 mg. for each 100 c.c., and at death it was 38.7 mg. (Table I).

TABLE I.

Summary of Results of Lethal Injection of Calcium Chlorid.

		Weight, kg.	Lethal dose, mg. for each kg.	Times the therapeutic dose	Blood calcium		Mg. of calcium chlorid for each mg. increase in blood calcium
					Before	After	
Normal	G267	6.8	225	27.27	11.5	36.5	9.0
dogs.....	2B	10.7	287.85	34.89	10.3	42.9	8.82
Jaundiced	G261	7.5	304	36.8	10.3	26.9	18.31
dogs.....	G166	7.8	469.23	56.8	10.9	38.7	16.87

The figures in the last column of the tabulation were obtained by dividing the number of milligrams of calcium chlorid taken for each kilogram of body weight by the number of milligrams for each 100 c.c. increase in the blood calcium content. These figures show that it requires approximately double the amount of injected calcium to raise the blood serum calcium content of the jaundiced dog to the same level as that of the normal dog, in spite of the fact that the blood calcium content is practically the same in the jaundiced and normal dogs both before and after injection of a lethal dose, suggesting a

calcium deficiency in the jaundiced animals which is not apparent in the blood serum calcium taken before the injection. This is borne out by the observation that although the lethal dose is larger in the jaundiced animal, the blood serum calcium contents taken at death are within a reasonable range of equality.

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CANCER OF THE THYROID

By Joseph L. DeCourcy, M.D.
of Cincinnati, Ohio.

A knowledge of the pathology and clinical course of cancer of the thyroid gland is of the utmost importance to the surgeon and the general practitioner as well, but far more important is the recognition and removal of precancerous conditions. I make this statement especially of cancer of the thyroid, rather than cancer in general because we have formed the opinion that radical removal of the thyroid, after it is possible to diagnose cancer clinically, is a useless procedure in so far as cure is expected. In every case of cancer of the thyroid, the diagnosis having been made clinically, which we have treated, death has been hastened by operation. Cancer has been found microscopically in a number of apparently benign adenomata, which we have removed however, and prolongation of life has been commensurate with cancer in other organs, possibly better. It has been our experience that cancer of the thyroid is rarely primary, but that it develops in practically every case in adenomata of years duration. This at once suggests that cancer of the thyroid could be eliminated in great part at least, by the early removal of all adenomata, and this is what we will attempt to show in the following data.

Series of goitre cases examined 3640. Of these, nine were diagnosed clinically as cancer. Four (4) of these nine were removed. One (1) died 18 hours after operation—sudden. One (1) died 10 days after operation—general weakness. One (1) died 6 months after operation—rapid growing recurrence. One (1) died 9 months after operation—recurrence.

Of the remaining five (5), two were needled with radium and one died twelve days following, from œdema of larynx, the other is living after two months. Other four which were considered inoperable could not be traced.

Of 850 thyroidectomies for adenomatous goitres, carcinoma was found microscopically in twelve cases and pronounced as doubtful in eight.

Of the twelve, two had recurrences within two years, the first in the submental region, this was removed and patient is still living after two months. She also had a recurrence of the right breast which is growing slowly, and which because of her condition it was thought unadvisable to remove.

The second case had a recurrence at the site of the right lobe and died twenty months after her first operation.

Of the eight doubtful cases, one had a recurrence of the cervical glands on the left side, and died thirteen months following without further surgical intervention.

Of the seventeen remaining cases, ten as positive and seven as doubtful—twelve are living and free from recurrence after three years four after two years, one after one year.

Of the 3640 cases examined, there were 1242 thyroidectomies for all types of goitre from January 1, 1919 to January 1, 1923. Of these, sixteen were truly cancer, while eight were doubtful. A true percentage of 1.3 per cent. and a doubtful percentage of about 2 per cent. of all operated cases during this time. Of all cases examined, cancer occurred in the doubtful percentage of about 0.7 per cent. or less than 1 per cent.

From the above figures we find that while cancer of the thyroid, on the surface is not very frequent, yet we do find that after a thorough microscopical

FIG. 1.—Cancer of thyroid.

examination of each specimen removed, that it is more frequent than ordinarily supposed, and it is even possible that we are still overlooking a number of carcinomata by our present method of sectioning. In our laboratory we have been sectioning only those gross areas which appear suspicious to the naked eye—occlusion of the vessels and so on. In adenomata, carcinomatous areas have been found in almost any area within the periphery of the gland, where degenerative changes are in progress.

Symptoms.—As was remarked earlier in the paper, it is not possible as yet to diagnose cancer of the thyroid early, because it is seldom primary, but rather occurs in adenomata of long standing, and when it finally displays itself in the surrounding structures or outside the periphery of the adenoma it is too late to effect even a palliative cure. Pain referable to a goitre and of rather frequent occurrence must always be looked upon as a suspicious sign. Dis-

tention of the veins of the neck, with extensive collateral circulation over the chest and even the abdomen must be looked upon with suspicion, although this may occur in benign substernal goitres. Enlargement of the cervical glands; a changing of a soft degenerated adenoma into a hardened nodular one, an increasing difficulty in breathing, swallowing, etc., are all evidence of cancerous changes. Diminished and roughened outline of the trachea on X-ray plates. The prognosis is necessarily bad.

Treatment.—All adenomata should be removed as soon as diagnosed.

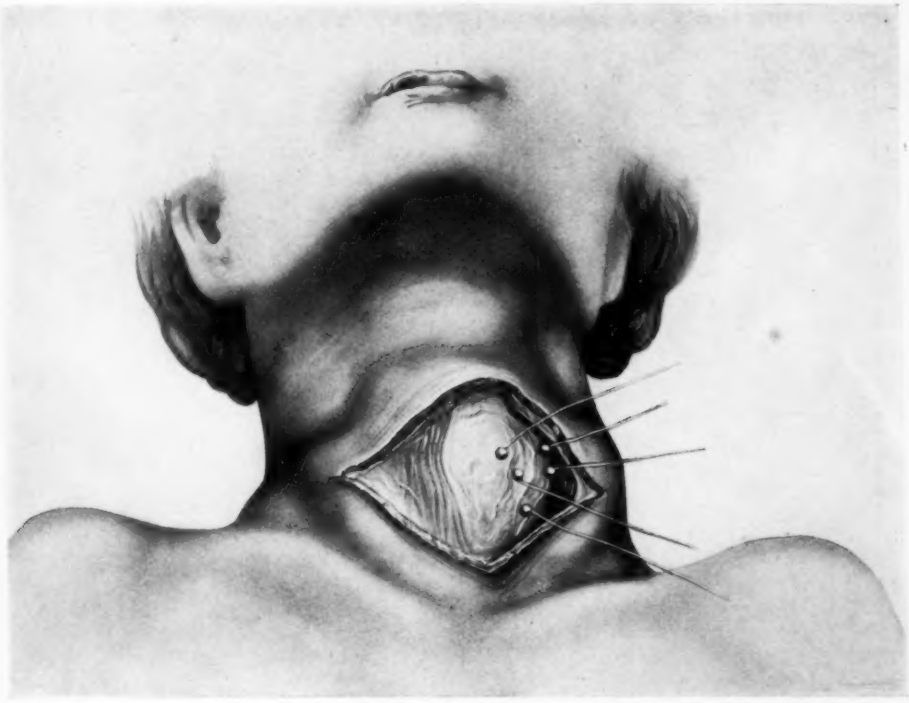

FIG. 2.—Needling cancer mass with radium. Needles are of 10 mg. each.

Surgery offers a 100 per cent. cure in adenomata of the thyroid with a mortality of less than 1 per cent. in all cases. If toxic, of course proper judgment should be used as to ligation, time to operate, etc. X-ray and radium have no place in the treatment of adenomata, in my opinion, and are more apt to do harm than good.

If the above treatment were carried out, cancer of the thyroid would be reduced to a minimum. When cancer has advanced however, to a stage where a clinical diagnosis is possible, then the method of treatment becomes problematical. At present I feel that the outlook is hopeless and that they will do just as well if left alone. I may be wrong. I do not, however, believe that surgery is indicated. Possibly needling with radium, at present offers the best means at our disposal. Deep X-ray therapy may find its place in the

treatment of thyroid cancer but I feel that it may do damage in the destruction of the parathyroid bodies.

Technic for Needling with Radium.—The wound is opened and the muscles separated as in the first step of a thyroidectomy. The needles are then inserted into one lobe of the mass, each needle being about ½ inch apart. The wound is left open and the needles removed in 12 hours, the following morning, or twelve hours later the wound is closed. The patient is then kept under observation for four weeks. Usually after two or three weeks the mass becomes œdematous and there is some danger of strangulation. About the fourth week the other lobe is needled.

Following this treatment should be given a prolonged course of X-ray therapy.

RESUSCITATION BY DIRECT MASSAGE OF THE HEART IN CARDIAC ARREST*

By Walter Estell Lee, M.D.
and
T. McKean Downs, M.D.
of Philadelphia, Pa.

Our purpose in presenting this case of cardiac arrest, which occurred during an exploration of the upper abdomen of a patient under ether narcosis, is: *First,* to call attention to the efficiency of cardiac massage in reëstablishing heart action in such a catastrophe. *Second,* to emphasize the simplicity of the procedure. *Third,* to suggest that restorative measures are never exhausted or completed in such an accident unless direct cardiac message has been tried.

Such accidents, though infrequent, have been seen by every experienced surgeon and anæsthetist. They present emergencies that are not easily forgotten, as they usually occur with startling suddenness and with no antecedent warning. Attempts at resuscitation are rendered inefficient, in many cases, by the demoralizing suddenness of the accident, and by the knowledge that restorative measures must be quickly successful or they will fail altogether.

It should not be forgotten in the management of these emergencies, that in massage of the heart we have a procedure which is sometimes successful even when the heart beat has been absent for several minutes. The number of recorded cases in which this method has been tried is small, and it has been successful in only about 25 per cent. of the cases in which it has been used; but when successful, it has acted dramatically, actually appearing to have restored the dead to life.

Heart massage implies manipulation of the heart directly, or indirectly through the diaphragm. Its purpose is to furnish rhythmic mechanical stimuli to the myocardium, and also to maintain a small circulation of the blood through the heart chambers and thus provide nutrition of the heart itself and of the vital centres of the brain. Obviously it can be successful only in those cases where arrest of the heart is due to reflex inhibition through the vagus, or to the presence in excess, of some quick acting and powerful poison, such as we have in our general anæsthetic agents, ether and chloroform. It is hopeless to expect results when the cardiac arrest is due to chronic disease of the heart muscle or of its vessels.

The subject was first studied experimentally in 1874, when Schiff showed that dogs which had been killed by chloroform inhalation could be restored by direct cardiac message, but in no other way; and that this method could be depended upon with some certainty when the heart had been quiescent as long as 11-½ minutes. Prus reported that the circulation in dogs could

* Read before the Philadelphia Academy of Surgery, May 5, 1924.

occasionally be restored after a cessation of half an hour. Crile and Dolley [1] maintain that massage should be performed simutaneously with artificial respiration.

Cardiac massage was first tried on a human in 1898, but the first successful case is reported by Darling and Lane in 1902. Bost [11] in 1923 was able to find only 75 cases in the literature, to which he added two more. In 20 per cent. of these cases the procedure was completely successful, in a few more the circulation was temporarily restored, for a few hours or days. To Bost's 77 cases we have added 23 found in the literature since 1918, which he did not include. This makes a total of 100 recorded cases and with the one we are reporting 101. But 25 of these cases were successful, including our own.

It had been our impression that accidents of this kind were most apt to occur in those who had taken their anæsthetic badly and when the induction had been accompanied by coughing and struggling, but the published reports do not bear this out. On the contrary in the few records in which this point is mentioned it is specifically stated that the induction of the anæsthesia had been particularly smooth.

In recent British literature there are careful articles by Norbury,[12] Gunn [13] and Levy,[14] giving the results of their clinical and experimental studies in this subject. Their findings are so remarkably similar in character they may be summarized as follows:

Artificial respiration they all agree is most important in conjunction with cardiac massage and must not be neglected. At times natural respiration may continue for several minutes after the heart has ceased beating but it is inefficient and little or no air is actually drawn into the lungs. Artificial respiration should be considered part of the technic of cardiac massage.

All these writers urge that massage be instituted early—within two to three minutes after the cessation of the heart beat. The importance of this is also emphasized by the published case reports. Only one patient was permanently revived when massage had been started after a lapse of longer than ten minutes after the heart had become quiescent.

The inefficiency of drugs is emphasized also by these studies. Gunn finds that adrenalin, in very dilute solutions, will counteract the effect of chloroform and of chloral on the perfused isolated mamalian heart; but in the intact animal, strong adrenalin solution thrown directly into the ventricles or heart muscle is apt to set up a ventricular fibrillation that will not be recovered from. It is obvious that if the heart and the circulation have stopped, drugs introduced under the skin cannot be absorbed. This was certainly demonstrated in the case which we are reporting. When the pulsations of the heart have been restored, but are still slow, feeble and irregular, intravenous infusion of salt solution containing a small quantity of adrenalin is advised by Norbury; Levy recommends pituitrin intravenously in the same circumstance.

Levy claims that the entire function of massage is to maintain the circulation and not to furnish mechanical stimuli. We cannot follow his argument. There is no doubt that the heart can be so squeezed as to cause

it to empty and partially refill, and thereby maintain a feeble and inefficient circulation, enough perhaps to keep the vital centres viable; but that cannot be the entire rôle of cardiac massage. The functions of irritability and contractility are eminently characteristic of the myocardium. They begin to be manifest in earliest embryonal life, when the heart of chicken and doubtless of other embryos, begins rhythmic contractions almost before the mesenchyme has become differentiated to muscular tissue about the primitive heart tube, and they continue without interruption for many years in man and other long lived animals. The greatest mechanical imperfections of the heart, the greatest changes in its histology, in its nutrition, or in its innervation are not sufficient to destroy its irritability or its contractility until the myocardium is too exhausted to respond, or until it has used up all of its stored nutriments. It is well known that the heart responds to any sort of irritation in the same way as other muscular tissues, namely, by contraction. All surgeons have seen various muscles twitch and contract when cut across, or have seen the muscles of an amputated limb respond by irregular contraction to the stimuli of pinching. A frog's heart separated from its body will beat for a period and finally become quiescent. After this time it will respond to mechanical stimuli of various kinds by strong contraction, and will continue to do so for hours, if it is kept moist. There is no reason to suspect that the mamalian heart differs in its irritability from the skeletal muscles of the same animal, or from that of cold blooded animals. Indeed they are known to react alike, save only that the mamalian heart loses its irritability earlier than that of cold blooded animals. Massage of the heart may, and probably does, maintain a feeble trickle of blood through the coronary circulation and perhaps through the brain, but it is not very efficient for this purpose. Its main effect certainly is to furnish a series of rhythmic mechanical stimuli. At first the heart resumes its function with one or perhaps two contractions to each stimulus; these natural contractions are infinitely more efficient to propel the blood than the squeezing of the hand, and must soon improve the nutrition of the myocardium, or remove enough of the toxic material so that it can resume automatic function.

1. *Methods of approach.* The first method employed was the thoracic route, in which an osteoplastic flap is turned back, giving direct access to the heart. This method has been abandoned; it is time consuming when time cannot be spared, it tends to increase shock and usually causes pneumothorax. But the consumption of time is the principal objection to this avenue of approach.

2. *The abdominal subdiaphragmatic route.* This is the method usually employed, as it is quick and easy, and seems the most natural approach. In many cases, the necessary midline upper abdominal incision will have been made when the accident occurs. Through this incision the hand is inserted and the heart after being grasped between the thumb and forefingers is rhythmically squeezed against the chest wall, which is supported on the outside by the

other hand. This method may fail, especially in adults, for in them the base of the heart, where contractility chiefly resides, and whence the heartbeat is normally propagated, cannot be reached through the diaphragm. If the heart has not been restored to activity within two minutes, further time must not be lost before incising the diaphragm and directly stimulating and massaging the heart.

3. *The abdominal transdiaphragmatic route.* Through an upper abdominal incision the diaphragm and pericardium are incised in an anteroposterior direction, the heart seized with the hand and rhythmically squeezed. By this method the heart has nearly always been induced to start beating, at least for a while, but the approach is difficult, especially the suturing of the diaphragm after the procedure is completed and this suturing, of course, must not be neglected.

Bost [2] advocates separating the diaphragm from its insertion to the ribs by a two inch transverse incision. This is stretched, the hand plunged into the left thoracic cavity and the heart can then be effectively massaged through the unopened pericardium. He states that this is an easier route of access to the heart, and that the hand plugs the diaphragmatic opening and usually prevents pneumothorax, and finally that the subsequent suturing of the diaphragmatic wound is easier than in any other method.

Whatever the approach the heart must be compressed at a slow rate, about 20 times a minute, for when it resumes its beat it will start slowly. When rhythmic beating is initiated, the massage should be stopped, for fear of interfering with the natural beat. During the whole time that cardiac massage is being used, artificial respiration must be continued until this function is again taken up automatically.

The necessity for rapid action must be borne in mind. Although three recoveries [8, 11] have been reported where the arrest is said to have lasted for ten minutes or more, yet time passes very rapidly in such emergencies, and the duration may have been overestimated. The sooner massage is instituted after cessation of the heart beat, the greater is the probability of resuscitation. Hypodermic stimulation should be given coincidently; it seems obvious that the intraventricular administration of adrenalin, as advocated by Crile, will be more certain and more efficient in its action if combined with massage. If the heart actually is arrested, it is doubtful if anything except direct massage will restore its beat.

Case E. R.—(Germantown Hospital, No. 615.) A colored teamster, age thirty-one entered the Germantown Hospital, March 13, 1924, on account of abdominal pain and digestive disturbance of three years' duration. Study in the medical ward led to a diagnosis of probable gastric or duodenal ulcer, and on March 24th he was transferred to the surgical service, and operated upon the same day. He received the usual preoperative preparation, including morphine sulphate, grains ¼, and atropine sulphate, grains 1/150 hypodermically one-half hour before starting anesthesia. Physical examination revealed no abnormality of the heart or lungs. The anæsthetic used was ether, given by the professional anæsthetist by the open drop method.

The patient started his anæsthetic well, but was very much excited during the second stage, struggled violently, breaking a heavy strap across his knees, and did not become quiet for several minutes; however, he was ready for operation within the usual time, and when the operation was started he was in good condition and fairly well relaxed. His pupils still reacted to light.

An upper abdominal right rectus incision was made, the stomach was picked up, and some traction made to expose the pyloris, when without warning he ceased to breathe, though the exposed viscera remained a good color. The pulse at the temporal arteries was at first strong but rapidly became weaker.

Artificial respiration was at once instituted but there was no response; Even rythmic testicular stimulation was unavailing. In about ten minutes it was reported that the pulse could no longer be felt at the temples. Hypodermic medication was then ordered. The operator inserted his right hand into the abdomen through the abdominal incision and felt that the heart was absolutely quiescent. At the same time, it was noted that the exposed abdominal organs and mucous membranes began to show a very deep cyanosis, rapidly approaching blackness.

The heart was then gently grasped by the thumb and fingers of the right hand and rythmically squeezed against the chest wall at the rate of about 20 times a minute. Artificial respiration was continued synchronous with this process of cardiac massage and 20 minims of adrenalin and 1/75 of a grain of atropine sulphate, which had been ordered previously were injected into the deltoid muscle. After 15 or 20 squeezes the heart began to respond to the mechanical stimulation by a feeble tremor which presently was followed by several twitchings and in about three minutes from the time the massage was first started it had resumed its regular contraction but at a very slow rate. The pulse then gradually returned at the temples, and the cyanosis began to diminish. After several more minutes, voluntary respiratory efforts were made; these became deeper and more efficient and regular, and artificial respiration was finally discontinued about 15 minutes after it had been commenced. It should be noted that at the time the adrenalin and atropine were injected there was no circulation to absorb these drugs from the tissues; and that the heart had resumed its beating before they could have been absorbed.

The operation which had been planned was then proceeded with. A gastro-enterostomy was done for a duodenal ulcer that was palpable and visible and a chronically diseased appendix was removed. The subsequent course of the patient was uneventful and he was discharged, free from symptoms, on April 8, 1924.

We have found 23 cases in the literature since 1918 which were not included in those collected by Bost in his article in 1923. Fourteen of these cases were reported by Norbury, who claims 3 successes.

Case I.—The patient, a French soldier,[3] had been wounded with retention of a shell fragment in the left lung. During the operation by Lefèvre for its removal, the patient's cardiac action ceased without warning. As the thorax was already opened, the wound was enlarged, the heart grasped through the pericardium, and rhythmically squeezed. It soon resumed its beating, and the wound was closed. The patient recovered consciousness, but died the next day. The cause of death was not evident.

At the same meeting of the Société de Chirurgerie de Paris, Chevassu reported a somewhat similar case.

Case II.—The patient was brought to LaPitié Hospital, apparently dead from a stab wound in the left chest. Although it seemed useless, the skin was hurriedly prepared and thoractomy was done. This revealed that there was a penetrating wound of the right ventricle and that the heart was almost motionless, though it was observed to twitch from time to time. The ventricular wound was sutured, which was enough stimulation to start cardiac contraction. The patient was sent to the ward, and for a time survived,

but died on the second day of sepsis. The autopsy showed a purulent pericarditis very possibly the result of the somewhat hasty pre-operative preparation.

CASE III.—This patient, recorded by DALY [4] was a patient in a British Base Hospital, who was almost ready to be returned to the front. During an enemy air raid, he was seriously wounded in the abdomen and left thigh and bled profusely. Although it was feared he might not survive the operation it was felt that the wounds must be repaired. During the operation his heart and respiration ceased; he was revived by subdiaphragmatic massage but died 22 hours later. Daly felt that this death was due to hemorrhage, and that if it had been possible to transfuse him, his life might have been saved.

CASE IV.—During an exploratory laparotomy under chloroform-ether mixture, another case reported by POWELL [5] the patient's heart stopped, but it was quickly revived by cardiac massage. The ultimate fate of this patient is not stated.

CASE V.—SHIPWAY reports a patient [6] who was a man of sixty years of age undergoing an exploratory operation under ether. When his stomach was pulled upon respiration ceased followed by a cessation of the heart beats. The usual measures of resuscitation failed, but subdiaphragmatic cardiac massage quickly revived him. The end result was not stated.

CASE VI.—Reported by APPERLY.[7] Was a stout woman undergoing a pelvic operation under ether. The abdomen was opened; when she was raised into the Trendelenburg position, her heart and respiration ceased, and her heart, felt through the diaphragm, was perfectly flaccid and immobile. The table was promptly leveled, and the heart massaged; the circulation was soon restored and the operation proceeded with. Near the close of the operation she was again placed in the Trendelenburg position but her pulse became so weak and irregular that it could not be maintained and the level position had to be restored.

CASE VII.—HAIM. During a cholecystectomy, started under local and completed under general anæsthesia, with Billroth's mixture of alcohol, chloroform and ether, the patient's heart and respiration stopped. Various measures were tried unsuccessfully for 20 minutes, when cardiac massage was begun. This restored the circulation after about five minutes, when the operation was completed. This patient made a good recovery from the anæsthetic, and had a normal convalescence.

CASE VIII.—This patient reported by PETTY,[8] was an elderly man, who was suffering from chronic indigestion. An exploratory operation was begun using chloroform and ether mixture for the anæsthesia. The induction of narcosis was quiet, without struggling. When his stomach was exposed and the pyloric end pulled upon, respiration ceased, and then the heart ceased beating. After ten minutes' trial of ordinary measures, without success, cardiac massage was started. It was successful, but could not be given up for seven minutes, at the end of which time the pulse was full and strong. The operation was abandoned and the wound repaired. It healed *per primam* and the patient had a normal convalescence.

CASE IX.—COLEMAN.[16] During an operation for gastro-enterostomy, the patient's heart and respiration ceased. Various measures were used unavailingly for one-half hour; at this time the heart was perfectly quiescent and flaccid. Cardiac massage and artificial respiration were started and persisted in for 45 minutes. After this time irregular cardiac contraction and occasional respiratory efforts were resumed, but they finally died away and ceased permanently after two hours.

CONCLUSIONS

1. The earlier cardiac massage is instituted after cessation of the heart beat, the greater is the likelihood of success. Time should not be lost waiting for hypodermic stimulation to act. If the circulation has actually stopped, it cannot act.

2. The quickest and the easiest method of approach is the best. This is usually the abdominal transdiaphragmatic route. If this is not successful within two or three minutes, the diaphragm should be incised, the heart grasped in the hand and directly stimulated.

3. No patient should be abandoned as beyond resuscitation until cardiac massage has been tried without success.

4. In about 25 per cent. of the recorded cases, cardiac massage has successfully resuscitated the patient.

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LATE RESULTS OF SPLENECTOMY FOR TRAUMATIC RUPTURE OF THE SPLEEN*

By Damon B. Pfeiffer, M.D.

and

Calvin M. Smyth, Jr., M.D.

of Philadelphia, Pa.

That the spleen is not essential to life, has been proven beyond any doubt, and the justification for its removal under certain conditions admits of no argument, but that life proceeds in the same orderly fashion after removal, is a point on which the last word has possibly not been said. The results of splenectomy for the various anemias, tuberculosis, abscess, etc., cannot be offered in evidence because we are dealing in these cases with an abnormal spleen under abnormal conditions. In splenectomy for traumatic rupture, we are dealing presumably with normal spleens in normal individuals, and it is to these cases that we must look for information. In reviewing the literature on this subject, one is impressed forcibly with the fact that there has been very little attempt to follow such patients for any length of time and in any numbers. The remote consequences of splenectomy should properly be sought in a study of the changes taking place in the various functions of the spleen, but as these are at present, more or less hypothetical, such a method is not practical for clinical purposes. The functions of the spleen have recently been summarized by Kahn. The more important functions of the spleen, according to our present knowledge are:

(a) The formation of white blood-cells, particularly lymphocytes; blood platelets are produced under normal conditions in the spleen, but other organs may take on this function vicariously.

(b) The splenic pulp serves as a place where the red blood-cells are discarded and undergo destruction and phagocytosis by the macrophages. This is a selective function, and determines which cells are to undergo destruction and which are to continue in the circulation.

(c) The spleen is a storehouse for iron, especially the iron which is liberated from the decomposition of the blood tissues. The iron output is increased after experimental splenectomy and in the hæmolytic anemias.

(d) That the spleen plays an important rôle in digestion, internal secretion, or metabolism, has not been established. The organ does act as a mechanical filter for bacteria and other particulate bodies.

Kahn's conclusions regarding the effect of splenectomy, are in general, that there is a temporary anemia of both red cells and hæmoglobin, with a leucocytosis which persists for about a year, and that there is an increase in total fats and cholesterin in the blood following the operation. No changes

* Read before the Philadelphia Academy of Surgery, May 5, 1924.

in the metabolism of sugar, CO_2, or in basal metabolism were noted. The statement is made, but not substantiated that splenic function is usually compensated within five weeks after splenectomy. Pearce and Krumbhaar, in an exhaustive experimental study on dogs, conclude that the effects of splenectomy may be summed up as follows:

1. An anemia of red cells and hæmoglobin, which tends to recover, the hæmoglobin being reduced more than the red cells.

2. Increased resistance of the erythrocytes.

3. Lessened tendency to jaundice when hæmolytic agents are administered.

Other changes which occur less constantly are also mentioned but are not applicable for clinical consideration. In general, the dogs returned to normal in from 2½ to 3 months. Wolferth has shown that substantially the same results follow splenectomy in albino rats. Krumbhaar and Musser found that in the monkey the anemia was much less marked than in dog or man, but that the resistance of the red cells was increased. Experimental work of many others, too numerous to mention, has laid particular stress on one or more of the above mentioned facts, but the findings in general are in accord with those of Pearce whose work included all of the data available at the time.

The results of splenectomy for traumatic rupture were reviewed by Lewerenz who collected the records of 135 cases up to 1900. Of these, 104 died; the majority in the first 24 hours, a mortality of 77.8 per cent. Since then the results have been far better, as is to be expected when viewed in the light of improvement in technic, earlier operation and better after-treatment. The operative mortality at present compares favorably with that of rupture of any other viscus. The later literature on traumatic rupture, and other matters pertaining to the spleen is apallingly voluminous, but the great majority of contributions consist in reports of one or more cases and are strictly surgical in character. There is a striking lack of published information regarding the more remote effects following removal of the presumably normal spleen. Staehelin collected the results in 21 cases, one of his own and twenty from the literature and personal communications. Analysis of this series gives valuable information regarding the blood picture following splenectomy, but the cases were followed only in one instance for as long as one year, and the majority for much shorter periods. It is apparent from analysis of these cases that no preliminary counts were made and in no instance with the exception of Staehelin's own case were the counts taken at regular intervals. The findings in all cases show a definite anemia of both red cells and hæmoglobin, but a wide variation in the degree of anemia. The leucocytes were increased in every case, but here the variations are even greater than in the red cells and hæmoglobin. Meyers reports a rather unique and intensive study of the blood picture in one case, in which 26 counts were taken following the operation, the first being taken after six hours and the last at the end of three months, at which time the patient's blood picture was on the up grade but still below normal. This study is not of any great value on account of the brief period covered. Hitzrot reported the results in five cases of traumatic rupture,

four of which recovered. His recorded observations cover periods of a few weeks or months but the impression is conveyed that the splenectomized individuals were all normal at the end of one year. In general the changes noted by Hitzrot were: 1. Anemia which gradually returned to normal in from 1 to 3 months. 2. Increased resistance of red cells. 3. Increased output of iron in stools. 4. Increase in total fat and cholesterin in the blood. 5. No change in opsonins and agglutinins.

The observations in 3, 4 and 5 are not especially significant as no preliminary tests were made and the normal figures are not constant. All four cases showed a leucocytosis varying from 19,800 to 68,000, but all were normal at the end of three months. No detailed blood counts are given.

Other changes following removal of the presumably normal spleen have been noted by many writers. These are (a) enlargement of the superficial lymph-nodes, (b) increased tendency to sleep, (c) increase in weight and appetite, (d) failure of proper growth, and (e) decreased resistance to infection.

A most interesting case is reported by Lee in which the patient had had splenectomy performed at the age of fourteen, for traumatic rupture. Fifteen years later Lee again opened the abdomen for intestinal obstruction and in the course of the operation found the entire small intestine studded with small tumors which looked like splenic tissue. Two of these were removed and were diagnosed as spleen by microscopic examination. Lee states that there were about 300 of these tumors, in the aggregate being equal to a normal spleen. The conclusion was drawn that spleen cells had been set free at the time of the rupture. This sort of thing may possibly be of importance in explaining the absence of anemia in some cases. The fact that accessory or supernumerary spleens occur in a percentage of cases, also has a definite bearing on the production of symptoms following splenectomy.

We wish to add to those already discussed, the reports of four cases in which the spleen was removed following traumatic subcutaneous rupture.

Case I.—M. A., aged fourteen, admitted to University Hospital, September 12, 1921, complaining of pain in the abdomen. The patient had been struck in the abdomen by a blow of the fist in a fight. He suffered severe pain at the time and was taken home. The pain became progressively worse and he was brought to the hospital in the patrol. When admitted the patient was pale, restless and markedly shocked. He complained of severe generalized abdominal pain. The abdomen was quite rigid and peristalsis was exaggerated. Both flanks were dull and the point of maximum tenderness was located over the right lobe of the liver. Blood count: Red blood-cells, 3,950,000; white blood-cells, 32,000; hæmoglobin, 65 per cent.

Operation.—Right rectus incision. Peritoneal cavity full of blood. Liver found to be intact, but palpation disclosed the spleen partially detached from the pedicle and a small laceration on the anterior surface. The incision was curved to the left and splenectomy done. The wound was closed without drainage. Convalescence was uncomplicated and the patient was discharged on October 21st.

Since operation the patient has had two attacks of abdominal pain, both following dietary indiscretions. He was admitted to the hospital for study. An X-ray examination of the gastro-intestinal tract was negative.

When seen two years after operation the patient was rather undersized, but had grown a good deal in the past two years. There was a moderate anæmia, as shown by the blood count, and a marked lymphoid hyperplasia of all the superficial lymph-nodes.

CASE II.—A. F., aged fourteen, admitted to Abington Hospital, February 16, 1922, complaining of pain in abdomen. He had been struck in the abdomen by a sled. This was followed at once by severe pain in the left side which was referred to the left shoulder. He was brought to the hospital at once. When admitted he was in pronounced shock, temperature 96, pulse 100, very poor quality. There is dulness in the left flank. Blood count: Red blood-cells, 3,400,000; white blood-cells, 28,000; hæmoglobin, 62 per cent.

Operation.—Left rectus incision. Peritoneal cavity contained large amount of fluid blood and clots in upper portion. Spleen ruptured. Splenectomy done. Wound closed without drainage.

Convalescence uneventful. Discharged March 7. One year and eight months after operation the patient was perfectly well. He had had no intercurrent infections, but the blood examination showed a definite though moderate anæmia. There was a general hyperplasia of the superficial lymphatics.

In January, 1924, this boy was struck by a train at a grade crossing and instantly killed.

CASE III.—D. K., aged sixteen, was admitted to University Hospital, February 8, 1920, complaining of pain in abdomen. While coasting, he had been thrown against a tree and "had the wind knocked out of him." He at once noticed a sharp pain in the left side and was unable to walk. The pain was also referred to the left shoulder and was particularly severe on inspiration. On admission to hospital, he was pale and apparently in great pain. The temperature was subnormal, the pulse small and running, rate 140. The respirations were slow, labored and painful. Abdomen, tense, tender, silent and dull to percussion in the left flank.

Operation.—Left rectus incision. Peritoneum filled with blood and clots, especially in the left upper quadrant. The spleen was completely detached from its vessels and lying free in abdomen in two pieces. The vessels seemed to be located in a mass of bloody cellular tissue and were oversewn. A large pack was placed over the pedicle and the wound drained with a rubber tube. The patient was given 750 c.c. of salt solution intravenously on the table.

The following day the blood picture was: Hæmoglobin, 61 per cent.; red blood-cells, 4,250,000; white blood-cells, 25,000. The differential count showed: Polymorphonuclears, 65 per cent.; lymphocytes, 27 per cent.; large mononuclears and transitionals, 7 per cent.; eosinophiles, 1 per cent. The packing was removed on the seventh day. Following removal of packing the temperature gradually climbed, and on March 2 the wound was reopened with the idea that a residual abscess had formed. No abscess was found.

The patient was discharged April 22 still running a temperature, but with a healed wound and no other complications.

In November, 1923, three years and nine months after operation, the patient has gained considerable weight but has, as he puts it, no "pep." There is a moderate anæmia, as shown by the blood count, and a generalized lymphoid hyperplasia.

CASE IV.—E. M., aged seven years, was admitted to Abington Hospital, November 11, 1920, complaining of pain in the abdomen. He had been struck by an automobile, which is said to have passed over the abdomen. He was admitted to hospital in the evening of same day in state of moderate shock. Temperature 97, pulse 120, respirations 24. Abdomen rigid, flat, no tenderness over liver or spleen. Diagnosis of intraperitoneal injury made, although unable to localize anything.

Operation.—Right rectus incision. Cavity full of blood. Spleen palpated and found to be ruptured. Left rectus incision (high) added and splenectomy done. Pulse rose to 180 during operation and saline solution given intravenously. Blood counts November 17, December 1, post-operative: refer to Table I.

Convalescence was uneventful and patient was discharged in good condition December 8. Examination three years after accident. Patient has grown quite tall, but has not gained weight as he should. He has had measles, whooping cough and repeated colds and sore throat since operation. His mother says that he does not seem to be very energetic. There is a rather marked anæmia with 65 per cent. of hæmoglobin, but a normal leucocyte count. There is a generalized lymphoid hyperplasia.

TABLE I

Table of Blood Count Results

Case	Time in relation to operation	Hb. Per cent.	RBC.	WBC.	Differential			Fragility of RBC.				Platelets
					Per cent.	Per cent.	Per cent.					
I.	Pre. op.	65	3,950,000	32,000	..	..	..	..	..	....	....	.....
	1 yr., 8 mo.	75	5,490,000	8,900*	66	24	10	0	0	....	....	.....
	2 yrs., 2 mo. Age 14.	80	4,160,000	5,600	60	..	10	3	0	0.70	0.30	200,000
II.	Pre. op.	62	3,400,000	28,000	..	..	..	..	..	....	....	.....
	27 days	56	3,160,000	15,500	..	..	..	..	..	....	....	.....
	1 yr., 9 mo. Age 16.	70	3,840,000	7,800	65	26	4	3	2	0.38	0.28	276,000
III.	24 hours	61	4,250,000	25,200	61	27	7	1	0	....	....	.....
	1 week	62	4,200,000	23,000	68	18	13	0	1	....	....	.....
	2 weeks	..	.....	17,000	..	..	..	..	..	....	....	.....
	37 days	70	4,100,000	14,000	68	28	3	1	0	....	....	.....
	3 yrs., 9 mo. Age 16	86	4,380,000	9,400	59	26	15	0	0	0.45	0.25	320,000
IV.	48 hours	..	.....	25,000	..	..	..	..	..	....	....	.....
	1 week	62	3,880,000	18,000	64	23	6	6	1	....	....	Excessive but not counted.
	30 days	72	4,320,000	12,000	58	28	7	5	2	....	....	Excessive but not counted.
	3 years Age 14.	65	3,460,000	8,200	80	11	8	0	1	0.38	0.28	321,000

*Patient had an acute abdominal attack, during which two white counts were taken—16,206 and 15,000, showing normal reaction to injection.

The accompanying table shows the results of observations on the blood pictures of these individuals. These four cases have been followed for periods ranging from one year and nine months in the shortest to three years and nine months in the longest. It will be noted that in every instance the patient still has a mild though distinct anemia. The white cell count has returned in all to within normal limits. All have pronounced enlargement of the superficial lymph glands. All complain of tiring easily. The changes in the resistance of the red cells is not constant. The platelet count is low in all if we take 600,000 as normal. No marked change in the structure of the red cells is apparent. These patients were all adolescent boys, and normal growth and development has not in any way been interfered with by splenectomy. How then should patients who have had splenectomy done for traumatic rupture be regarded? Whatever else they may or may not have, they show a secondary anemia which while of mild degree, is quite definite. The symptoms which these cases exhibit

have been attributed by various writers to many different things, but with the exception of the lymphoid hyperplasia, the symptoms might well be due to the anemia. If this be true, it follows that the anemia should receive active treatment, for from a standpoint of general health there is a great difference between three and four million red cells per cm. One individual is well—the other is, if not actually sick, at least below par. Does the fact that the anemia is due to removal of the spleen, make it different from any other secondary anemia from the standpoint of treatment? Injection of protein free splenic extracts will produce an increase in red cells and hæmoglobin in normal experimental animals, but Pearce and Krumbhaar found that feeding of fresh beef spleen to splenectomized dogs produced no change in the blood picture.

Leake has recently shown that there is a decided increase in red cells and hæmoglobin in normal men, following the oral administration of combined splenic and red bone marrow extracts, and he suggests that the procedure may be of value in the treatment of certain anemias. No data is available as to the value of such therapy in splenectomized individuals, but it would seem to be worth trying. The administration of iron by hypodermic or intravenous injection is indicated in these cases and in our series Case III which shows much the best blood picture of the four, was the only one to receive such treatment. Small blood transfusions during convalescence would seem a rational procedure in stimulating the blood forming organs at the time when such stimulation is most needed.

CONCLUSION

1. Individuals splenectomized for traumatic rupture usually show a definite and persistant anemia which in our series did not fully recover under the ordinary conditions of life, and therefore requires prolonged observation and treatment.

2. That the spleen exercises an important function, is evidenced by the hyperplasia of lymphoid tissue throughout the body, and of splenic tissue which remains after splenectomy.

3. Decreased bodily vigor and resistance, often noted clinically and experimentally, may depend on anemia, but in the present state of our knowledge, it is impossible to exclude endocrine or metabolic disturbances as yet unknown.

4. There is no evidence of such adverse influence on health or longevity as to contraindicate splenectomy for traumatic rupture, which is ordinarily the operation of choice.

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MALIGNANT TUMORS OF THE KIDNEY IN CHILDREN

By Frank Hinman, M.D.

and

Adolph A. Kutzman, M.D.

of San Francisco, Cal.

From the Department of Urology, University of California Medical School

It is a well-known fact that the kidney is not a rather uncommon seat for malignant disease during infancy and childhood. The type of tumor found is in the vast majority of cases of the mixed embryonic type, though various names have been applied. In many respects these tumors have and still present the problems and diversities of malignant tumors of the testicle. By the realization of embryologic and pathologic information we have been able to see various similarities between these malignant tumors of the infant kidney and the teratoma testis. This is not at all surprising since we know that during the embryological development of the organism the genital and urinary tracts have origin in very close proximity, namely, the urogenital fold is the anlage of both the mesonephros and the genital gland. These tumors, mixed in constituent tissues, as in the case of testicular tumors, are highly malignant and great destroyers of life. They are a singular and characteristic renal growth and have presented great problems as to pathogenesis. The presence of such a case on the Urologic and Pediatric Services of the University of California Hospital has prompted this report because of the large size of the kidney tumor (4500 grams-9.9 pounds).

In reviewing the literature there have been found several cases, rather large and unusual in size. Van der Byl's (Bland-Sutton) case weighed 36 pounds; Spencer Wells' case (Ency-Franc: D'Urol.) weighed 19.8 pounds, while Israel's was 18.7 pounds and Shepherd's 10 pounds. Strong reported a remarkable bilateral case in which the first tumor removed by operation weighed over 2½ pounds; about a month later autopsy revealed a tumor mass of 8 pounds in the remaining kidney. These cases are extraordinary, the usual size varying from 1 to 4 pounds.

Case.—A. C., female of Italian parentage, age six years five months, entered the University Hospital, August 25, 1922, with the complaint of swelling of the abdomen. The family history was negative. In the past history, feeding and development were normal except that she did not talk or walk until fifteen months. The only disease she had had was diphtheria, eleven months (October, 1921), before entry. This responded to four injections of antitoxin but leaving a slight difficulty in speech.

The present illness dates back eight months prior to entry. Following the attack of diphtheria in October, 1921 to December, the child appeared normal except for a poor appetite and no gain in weight. At this time no urinary or other symptoms were noted. Suddenly, in December, the patient was seized with abdominal pain. Examination by the parents disclosed a tumor in the left abdomen. There were no gastro-intestinal symptoms present. Several days later a fever developed which was of about one month's duration;

this was accompanied by vomiting during the same time. She was under the care of various physicians for several months, but the mass continued to increase rapidly in size up to one month before entry. At that time the parents think that it decreased some in size. Three weeks before entry the patient again was seized with severe abdominal pain, especially on the left side, radiating to the chest and pelvis. This was more or less continuous up to the time of entry but unaccompanied by urinary disturbances, fever, diarrhœa or constipation. During this time the patient had been up and around and playing. The parents think that there has been some loss in weight.

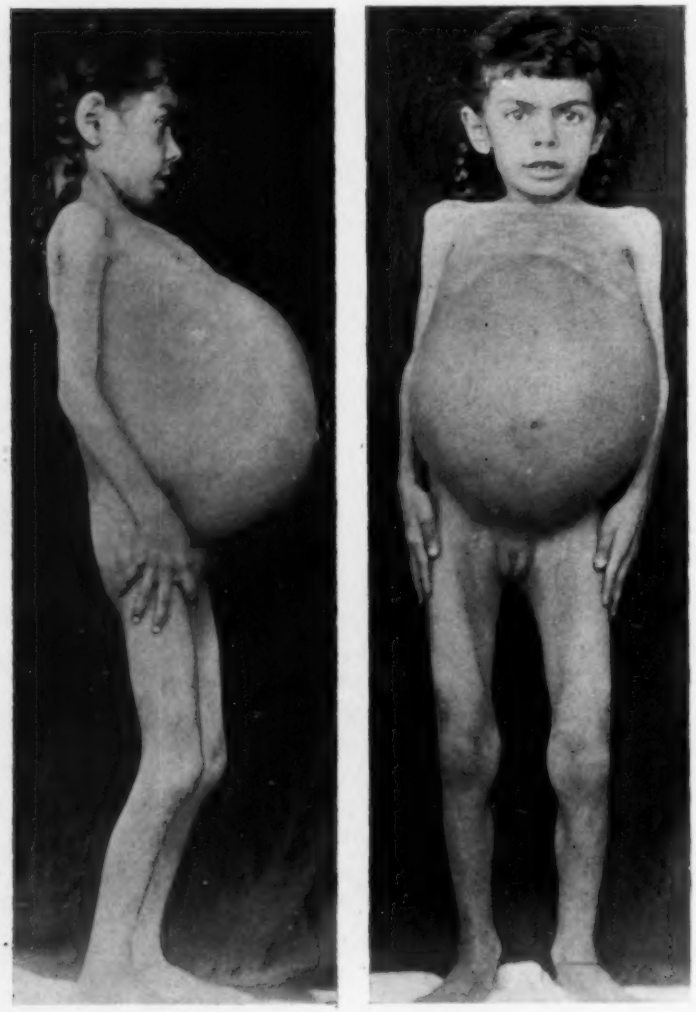

FIG. 1.—Photograph showing front and lateral view of patient. Note the marked abdominal distention.

Physical examination showed a thin, emaciated and underdeveloped girl lying in bed complaining of pain and discomfort in the abdomen. The skin was dark in color. Marked hypertrichosis on the back and extremities. The posterior cervical, axillary and inguinal lymph-nodes were palpable. The head showed some frontal bossing. The eyes, ears, and nose were negative. The tonsils were enlarged and reddened. The chest appeared shortened due to the abdominal protrusion. There was marked emaciation and flaring of the costal margins. The heart was pushed to the left about 2 cm. outside the left nipple line. No murmurs. The lungs were negative except for shallow expansion. The abdomen was markedly and uniformly distended (Fig. 1). The superficial veins were markedly distended. Palpation revealed an almost stony hard resistance over the entire left side from the costal margin to the iliac crest and extending to the right as far as the midline above and the right posterior iliac crest below. The border thus formed was round and smooth, forming almost a straight line. In the left loin there was a bulging about the size of an orange and also of a stony hard consistency. The surface of the tumor being

covered with the intestines gave the impression of cyst formation. There was no evidence of ascites. Extremities negative. No œdema. Rectal examination showed the pelvis to be free from tumor.

Laboratory Data. Blood.—Hæmoglobin (Sahli), 40 per cent.; red blood-cells, 3,272,000; white blood-cells, 15,500; polymorphonuclears, 75 per cent.; small mononuclears, 23 per cent.; transitionals, 2 per cent. The red blood-cells showed slight anisocytosis and central pallor but no poikilocytosis or polychromatophilia.

Urine.—Cloudy, amber cloud, acid reaction. No sugar or albumen. Sediment showed no red cells, pus cells or casts

Blood Wassermann.—Negative in two antigens.

Nose and Throat Cultures.—Streptococci and staphylococcus albus.

Von Pirquet.—Negative in 72 hours.

Phthalein.—First hour, 40 per cent.; second hour, 20 per cent. Total, 60 per cent.

X-ray Report.—Left chest rather mottled. Heart pushed upward by high diaphragm. No evidence of bone metastases.

A clinical diagnosis of sarcoma of the left kidney was made and the patient transferred to urological service.

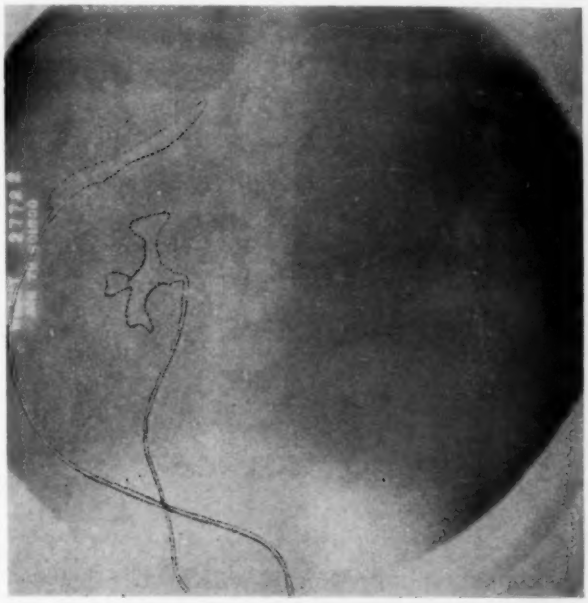

FIG. 2.—Photograph of pyelogram showing catheter in left side to cross and lie outside of right catheter due to the tremendous size of the tumor. The left pelvis shows a marked deformity. The right pelvis is normal in outline.

Cystoscopic Examination.—Under light ether anæsthesia a child's cystoscope was easily introduced. Bladder negative, ureteral orifices in normal position. Both ureters catheterized to the pelves with F5 bismuth catheters. The urine drained quite readily from the right catheter while that from the left was bloody and flowed very slowly. Functionally, phthalein appeared in three minutes on the right side and returned 30 per cent. in 15 minutes; no function was obtained on the left side. Pyelograms were made of both kidneys. The capacity of the left side was 8 c.c., while that of the right was 7 c.c. Examination of the plates showed the catheter in the left side to cross and lie outside of the right catheter far over on the right side of the body as though the patient had a right side double or horseshoe kidney. Pyelogram of right side showed that kidney in normal position with a normal appearing pelvis; the left side revealed a long oblique streak-like shadow extending from the top of the catheter upward to a point to the right of the spinal column at about the level of the IX dorsal vertebra. This was interpreted as meaning that the entire pelvis was invaded and destroyed and the shadow possibly might be extravasation of the pyelographic medium into tumorous tissue. Impression: Tumor of left kidney with ureter pushed out over its inner border so as to come to lie on the right side of the body (Fig. 2).

Operation.—Under ether anæsthesia the usual nephrectomy incision was made beginning from the left sacrospinalis muscle. Due to the tremendous size of the tumor the incision was extended across the lower abdomen over to the right side. The tumor mass was freed with difficulty due to the numerous adhesions everywhere. The tumor being rather cystic, was tapped with a trocar and about 100 c.c. of sanguinous fluid removed.

This made it possible to clamp and cut the pedicle which was smaller even than for a normal kidney. Following the removal of the tumor the patient went into shock. Stimulation with adrenalin and caffein failed to help and the patient died at the close of the operation.

Pathologic Examination. Gross Pathology.—Specimen consists of spherical tumor weighing 4.5 kg. (9.9 pounds) and measuring 30 cm. in dimensions. It is surrounded by a firm, thick capsule, except in one place, where the capsule is thin and rupture of the mass has occurred. The tumor is fairly firm and elastic, except for small areas which have a cystic sensation. On section through the middle of the mass is seen a fibrous capsule varying from 0.1 to 1.0 cm. in thickness. The cut surface presents a varied picture due to multiple areas of hemorrhagic extravasation, degeneration and necrosis with multiple cyst formations. The major part of the mass, however, presents a solid yellowish-white cellular surface almost like lard in appearance, such as characterizes hypernephroma. The tissue is everywhere quite friable and lacks supporting stroma (Figs. 3 and 4).

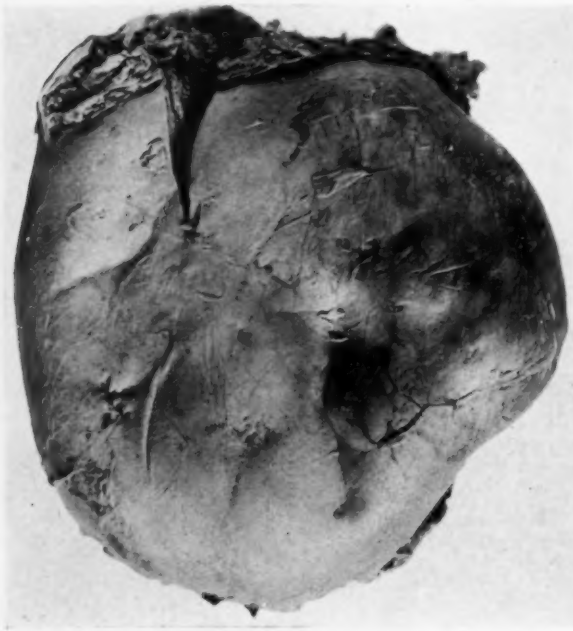

FIG. 3.—Photograph of gross specimen of embryonic mixed tumor of reported case. The tumor was 30 cm. in diameter and weighed 9.9 pounds.

Microscopic Pathology.—Section shows a picture which is uniform throughout, characteristic of an extremely malignant adenocarcinoma. The individual cells are small, slender, columnar in type. The glands are well formed and packed closely together with abundant proliferation in and about them of similar cells which have escaped bounds. Indeed, in areas the gland formation is almost entirely lost and replaced by solid fields of these small hyperchromic cells which show abundant typical and atypical mitoses. There is a small amount of loose stroma. Large areas of necrosis are seen. Blood-vessels are infrequent. No heterologous tissue is seen that would suggest a teratomatous origin. The glands are all lined by several layers of cells, often encroaching markedly on their lumina. The cells bear no direct resemblance to adult renal cells, nor does it reproduce the structure of any adrenal tumor either medullary or cortical. The cell type is characteristic of renal blastoma to which the origin of this tumor can undoubtedly be attributed. Other sections through the capsule show a few atrophic sclerosed hydronephrotic glomeruli. The remainder of the thinned-out parenchyma has been replaced by connective tissue and other chronic inflammatory elements (Figs. 5–8).

It belongs to the rare group of tumors of the kidney occurring more commonly in infants than adults, rapidly growing and malignant but showing little tendency to metastasize, known as embryonal adenocarcinoma. *Diagnosis.*—Embryonal adenocarcinoma of left kidney.

Discussion.—Since the tumor in the reported case is of the "mixed embryonic type," the one most usually found in infancy and childhood, the

following discussion will therefore be entirely devoted to them. The study of malignant tumors of the kidney is an interesting one. Occasionally some of the other malignant types, as the hypernephroma or carcinoma (Franck), may be but rarely found. The benign types which are equally as rare, usually are fibromata, lipomata, fibrolipomata, adenomata and fibrocystic tumors.

Pathogenesis.—Prior to 1870, malignant tumors of the kidney in children as well as in adults were considered as being of a carcinomatous nature. The terms "medullary cancer," "encephaloid cancer" or "encephaloid degeneration" were used to designate malignant renal growths (Parker, 1850; Shepherd, 1858; Barthez, 1864; Faludi, 1865, etc.).

In 1870, Catanni (Shannon) was the first to recognize the occurrence of sarcomatous elements in kidney tumors. Eberth, in 1872, noted that in reality there were tumors probably containing more than one type of tissue; he attempted to explain the presence of the muscle elements as being due to Wolffian body inclusions in the kidney. Cohnheim several years later (1875) thought that the striated muscle fibres, especially as found in rhabdomyomata, originated from the primitive vertebræ because, as he pointed out, the original anlage of the urogenital tract was in almost direct contact with these primitive somatic vertebræ. Jacobi, in 1884, collected cases in children from the literature and considered them as sarcomata. That these tumors were found at birth was noted by Paul in the same year when he reported "a congenital sarcoma of the kidney."

In 1894, there appeared the epochal paper of Birch-Hirschfeld. He collected a series of cases from the literature and brought forth the hypothesis that these "embryonic adenosarcomata" had their histogenic origin from the Wolffian body, thereby tending in a way to corroborate Eberth and Cohnheim. Several years later (1899) there appeared the very able discussion of Wilms. He not only agreed with Birch-Hirschfeld, but went further, deriving these tumors from embryonic tissue in its very earliest development, the myotome, sclerotome and nephrotome being considered in the process. By this hypothesis the striated muscle was derived from the myotome; bone and cartilage from the sclerotome or vertebral anlage; glandular elements from the Wolffian body; while the fibrous tissue, fat, smooth muscle and vessels originated from the mesenchyma. It must not be forgotten that at the stage indicated all the elements found in these tumors are in close proximity and that various degrees of displacement of these tissues may account for the variations encountered in these tumors. The hypothesis is a feasible one and probably is the one most readily accepted at the present time. Since Wilms, other very good discussions have appeared (Muus, Trappe, Jenckel, Klose, Garceau, Watson and Cunningham, Herzog, Ribbert, Busse, Fraser, etc.). Busse later attacked Birch-Hirschfeld's theory, bringing forth the fact that remnants of the Wolffian body had never been found in the kidney. He, as well as Muus, considered these mixed tumors as originating from the renal blastema and that the presence of the various tissue types could be explained by metaplasia. Ewing is of the opinion that the latter hypothesis is probably the most acceptable and by it can be explained why some tumors have the appearance of an embryonal adenocarcinoma.

The opinion on these embryonic mixed tumors is far from uniform and numerous names have been applied to them in the literature (adenomyosarcoma, embryoma, embryonal adenosarcoma, embryonic sarcoma, mesothelioma, embryonal adenocarcinoma, myxosarcoma, Wilms' tumor, teratoma, etc.). It can be seen that the terms merely designate the type of tissues found. Notable papers have appeared from time to time but very little, if anything, has been added to the original theories. It is possible that the simple tumors or so-called "sarcomata" may be explained upon Birch-

Hirschfeld's theory and the more complex types according to Wilms' theory. It is best for the present to consider them as being mixed tumors of some obscure embryologic origin. Indeed, the problem here is as perplexing as that of the testicular tumors. Probably the explanation of one will give some clue to the other.

The modern views regarding the pathogenesis of "mixed tumors" of the kidney may, therefore, be summarized in three groups (Fraser):

(*a*) That their origin is due to inclusions of Wolffian body tissue which has become displaced and persists among the cells of the developing kidney or metanephros (Birch-Hirschfeld).

(*b*) That aberrant cells of the myotome and sclerotome are responsible for the tumor growth and that the apparent mixed character is to be explained by the varying constituents which enter into the ultimate formation (Wilms).

(*c*) That these tumors are not due to inclusions from extra-renal sources, but are derived from the embryonic tissue of the true kidney, this tissue persisting and becoming metamorphosed into cellular structures of various types (Busse, Muus, Ewing).

Classification.—No definite classification of kidney tumors has as yet been arrived at, due to the uncertain knowledge of pathogenesis. Many classifications have been brought forward. We offer the following simple one from Eisendrath:

I. *Primary Neoplasms of the Parenchyma.*

1. Epithelial type.
   - (*a*) Adenoma.
   - (*b*) Carcinoma.
2. Connective tissue type.
   - (*a*) Benign—fibroma, myxoma, chondroma, leio and rhabdomyoma, angioma.
   - (*b*) Malignant—sarcoma.
   - (*c*) Embryonal adenomyosarcoma—also called teratoma or mixed-cell tumors.
3. Neoplasms due to misplaced adrenal rests—hypernephroma.

II. *Primary Neoplasms of the Renal Pelvis.*

1. Epithelial type.
   - (*a*) Papilloma.
   - (*b*) Papillary carcinoma.
   - (*c*) Epithelioma (squamous cell).

Pathology.—Grossly, these tumors may assume large proportions. They grow apparently from within so that they come to lie within a distended renal capsule, their rapid growth being a notable feature.

Macroscopically they usually are either solid opaque tumors or multiple cystic. If the latter, they have been found to be not unlike the congenital cystic kidney. These cysts have been found to contain clear or straw-colored fluid. Areas of necrosis and hemorrhage may occasionally be encountered as in other

tumors. Cross-section shows lobulation of the tumor tissue or multiple cyst formation with areas of hemorrhagic necrosis. The former may usually be accounted for by the preponderance of glandular, fibrous, muscular or cellular tissue.

Microscopically a very complex picture may be presented and yet a characteristic distinguishing one. As the many names in the literature indi-

FIG. 4.—Photograph of cross-section of tumor showing multiple cyst formation, areas of hemorrhagic extravasation, degeneration and necrosis. Note the enclosing thick firm capsule.

cate, various types of tissues may be encountered. The picture most usually seen is a mixed embryonic one. According to Ewing "the usual composition is one of isolated tubules of high cylindrical or cubical cells with indistinct lumina surrounded by broad zones of indifferent spindle-cells, on which is based the designation of adenosarcoma." The rapid growing tumors are usually cellular, showing practically no differentiation. If these cells are in excess, the term "adenosarcoma" has been used to designate them. If the tubular elements are dominant as in the case reported the term "adenocarcinoma" has been applied. In some, abortive attempts at glomerular formation can be seen. Many other types of tissue are occasionally found such as smooth or striated muscle, elastic fibres, myxomatous tissue, cartilage, bone and fatty tissue. The whole picture is of a mixed embryonic type. Should metastases occur, they are usually of the cellular or sarcomatous type, although striated muscle cells have been reported in lung metastases. Fraser has brought forth the idea that these tumors may be of low malignancy at first,

at which time it is mostly of adenomatous tissue and later changes to one of high malignancy, grows rapidly, assumes a sarcomatous structure and infiltrates quite markedly.

TABLE I.

Analysis of Statistics Relative to Incidence of Kidney Tumors in Human Beings.

	Author	Number of cases	Number of renal tumors	Percentage	
Frequency of kidney tumors	Kelynack	4,500	9	0.2	
	Kuster	37,000	23	0.06	
	Wagner	4,505	9	0.019	
A. Adults	Kaufman	1,035	87	8.00	
		47,040	128	0.25 (1 in 400)	
B. Children	Fraser	15,000	7	0.04	
	Cheney	2,260	1	0.04	
	U. C. Hospital (1918-1923)	3,210	6	0.18	
		20,470	14	0.06 (1 in 2500)	
Relative frequency among tumors	Warthin	2,000	8	0.3	
	Williams	8,371	25	0.4	
	Reiche	11,930	80	0.7	
	Kelynack	1,400	6	0.4	
A. Adults	Muller	521	3	0.5	
		27,222	122	0.5 (1 in 200)	May be as high as 2 per cent. (Wood)
B. Children	D'Espine and Piso	383	78	18.0	
	Hirschsprung	29	15	49.0	
	U. C. Hospital (1918-1923)	62	6	9.6	
		484	99	20.4 (1 in 5)	
		Number of cases of renal tumor	Number in children		
Relative proportion of children to adults	Morris	132	45	34.	
	Albarran	247	63	25.	
	Rohrer	115	37	32.	
	Kelynack	160	83	52.	
	Albarran and Imbert	589	173	29.	
		1,243	401	32.2 (1 in 3)	

			Mixed tumors		Hypernephroma		
			No. of cases	Per cent.	No. of cases	Per cent.	
Relative frequency of mixed tumors to hypernephromata	Israel	43	2	4.6	17	39	
	Albrecht (Hyman)	32	0	0.0	28	87	
	Barney	74	0	0.0	27	36	
	Wilson	92	4	4.3	71	76	
	Watson	89	2	2.2	45	50	
	Block (Israel)	126	5	3.9	86	68	
	Binney	114	31	27.0	43	38	
	Hyman	40	8	20.0	28	70	
	Albarran and Imbert	380 (adults)	10	2.6	85	22	Many tumors in this series classified as epitheliomas and not included here.
		220 (child.)	49	22.0	5	2	
	Ipsen	42	2	5.0	17	40	
	Derrick	29	4	14.0	18	62	
	(Average)	1,281	117	9.9	470	36.6 (proportion about 1:4).	

Incidence.—Malignant tumors of the kidney in children are rather uncommon. An analysis of the accompanying tables yields some interesting data (Tables I–II). The frequency of renal tumor in adults is 0.25 per cent. (1 in 400), whereas in children it is much rarer—0.06 per cent. (1 in 1600). These figures would seem to indicate that the occurrence of renal growths in children is about four times as rare as in adults. In animals the rarity is even greater—

TABLE II.

Incidence of Kidney Tumors Among Animals.

	Author	Animal	Number of animals	Number of kidney tumors	Percentage	Remarks
Frequency of renal tumors in animals	Chicago Lab. of Bur. Animal Industry	Hogs	2,000	52	2.6	47 were embryonic adenosarcomas. 5 sarcomas.
	Haaland	Mouse	300	2	0.66	Hypernephromas and adenocarcinomas.
	McCoy	Rat	100,000	11	0.01	Adenomas, carcinoma and papilloma.
	Wooley and Wharry	Rat	23,000	3	0.01	
	McCoy	Squirrel	250,000	8	0.003	Some reported as angiosarcoma.
	Curtis	Bird	880	5	0.5	
	Burger	Bird	852	0	0.0	
	Kimura	Horse	77,224	9	0.01	
	Trotter	Cattle	305	1	0.32	
	Sticker	Cat	21	0	0.0	
	Roffo	Cat	7	0	0.0	
	Murphy	Cat	11	0	0.0	
	Slye	Mouse	33,000	16	0.04	
			487,000	107	0.02	(1 in 5000).
			Number of tumors			
Relative frequency among tumors in general in animals	Sticker	Swine	12	7	58.3	Most of mixed type.
	Chicago Lab.	Hogs	93	52	55.8	
	Tyzzer	Mouse	83	4	4.8	All hypernephroma.
	McCoy	Rat	103	11	10.6	
	Wooley and Wharry	Rat	22	3	13.6	
	Curtis	Bird	79	5	6.3	
	Wernicke	Bird	34	3	8.8	
	Burger	Bird	12	0	0.0	
	Joest and Ernesti	Bird	163	0	0.0	
	Scott	Rabbit	39	5	12.8	Tumors benign adenomas resembling Wilm's tumor.
	Sticker	Horse	509	37	7.2	
	Sticker	Cattle	78	10	12.8	
	Sticker	Dog	766	19	2.4	
	Slye	Mouse	5,000	16	0.3	
			6,992	172	2.4	(1 in 50).

0.02 per cent. (1 in 5000). The hog, however, which is the only animal having kidney tumors similar to those in children, shows an incidence which is much higher; thus, in statistics from the Chicago Laboratory of the Bureau of Animal Industry, 52 kidney tumors in hogs were found in 2000 specimens of all animals (2.6 per cent.). Mixter, in 12 years, found but 27 kidney tumors in the Boston Children's Hospital and his personal practice. Loughnane found but 35 cases in London hospitals during 12 years; however, in reviewing the statistics of the Registrar General of Great Britain for the

same period, he found 557 deaths from "cancer of kidney and suprarenal capsule" under the age of fifteen years. Squier, in 324 adult surgical kidneys, found 24 tumors (7.3 per cent.).

The relative frequency of kidney tumors among tumors in general is 0.5 per cent. (1 in 200) for adults. Wood has put it as high as 2 per cent. In children it is very much greater—20.4 per cent. (1 in 5). This is borne out by the figures of D'Espine and Piso (Porter and Carter), who found the following proportion in 393 cases of tumor in children: eye and orbital structures, 52 per cent.; kidney, 20 per cent.; bone, 17 per cent.; brain, 5 per cent.; abdomen and pelvis, 4 per cent. In animals this proportional frequency is much less—2.4 per cent. (1 in 50).

Analysis of our tables as to the relative proportion of children to adults shows it to be 24 per cent. (1 to 4). Rohrer (Wood) is quoted as stating that one-third of all kidney tumors occur in children.

Comparison of the relative frequency of the mixed tumors to the hypernephroma shows that the former constitute about 9.1 per cent. and the latter 36 per cent. of all kidney tumors. The figure for hypernephroma is probably a little low, 60–80 per cent. being more correct. Of interest here are Albarran and Imbert's figures which show in children the preponderance of the mixed tumor and very few hypernephromata and vice versa in adults. They found in children 49 mixed tumors and 5 hypernephromata as against 10 mixed tumors and 85 hypernephromata in adults. This is in accord with the general opinion that mixed tumors are the renal tumors of infancy and childhood and the hypernephroma of adult life.

As to the side affected we find that both sides are attacked with about equal readiness. Thus, in 520 cases in children, we find that the right side was

TABLE III.

Occurrence of Mixed Tumors of Kidney in Children as to Side.

	Author	Number of cases	Right	Left	Bilateral	Not stated
Relative frequency as to sides (children)	Loughnane	35	17	13	1	4
	Willan	59	26	31	0	2
	Walker	141	58	73	10	..
	Binney	27	13	14	..	..
	Watson	100	37	41	6	16
	Albarran and Imbert	138	65	69	4	..
	Total	520	216	241	21 (4%)	22

involved 216 times, the left 241 and 22 not stated (Table III). In this figure 21 (4 per cent.) were bilateral. Isolated cases of bilateral involvement may be occasionally found in the literature. Van der Byl reported a case in which a nephrectomy had been performed for a malignant kidney tumor; 4½ years later the remaining kidney developed a "sarcoma." In Strong's case a kidney tumor weighing 2½ pounds was removed. The child died one month later and autopsy revealed an 8-pound tumor of the other kidney. Steadman in 1881 reported a case of bilateral tumors in a four-year-old

girl. Of interest also is J. W. Wood's case; autopsy on a three months' female child revealed the absence of the right kidney while the left kidney contained "a cancerous growth" 5 inches long and 3 inches in breadth. Other cases of bilateral involvement have been reported (Fraser, Napier).

Analysis of statistics gathered from the literature shows the involvement of sex to be equal; thus, in 1037 cases, there were 500 males, 500 females and 37 not stated (Table IV).

Analysis of collected statistics as illustrated by the accompanying chart show that the embryonic mixed tumors are the kidney growths in childhood

TABLE IV.

Occurrence of Mixed Tumors in Kidneys of Children as to Sex.

	Author	Number of cases	Male	Female	Not stated
Relative frequency as to sex in children	Loughnane	557	272	285	..
	Kelynack	66	30	36	..
	Binney	31	9	17	5
	Hyman	8	3	5	..
	Walker	130	55	51	24
	Albarran and Imbert	138	80	55	3
	Watson	100	50	45	5
	McCarty	7	1	6	..
	Total	1,037	500	500	37

(Fig. 9). Note that the peak is reached in the first 5 years of life. Comparison has been made with the hypernephroma which is the most common occurring kidney tumor and is the malignancy in adult life after the fourth decade. Rohrer (Kelley, J. T.) claims that one-third of all cases of primary renal growths occur in children; of 115 cases he found that 37 occurred before the age of 10 years, 31 cases being in children before the age of five years. Steffen in 219 cases found that 168 occurred in the first five years. Walker, analyzing 142 cases, noted 116 during the first 5 years. Hyman, in analyzing the literature, found that in 165 cases, 131 were found within the first 6 years. Taylor in collected statistics found 106 of 130 cases as occurring during the first 5 years and of these 57 were in the first 2 years. Loughnane, in the 557 cases from the Registrar General, found that 430 died in the first 5 years and 127 from 5 to 15 years. Binney, Albarran and Imbert, Wood and others, all substantiate the fact that the major number of cases occur within the first 5 years. These tumors may also occur at birth. Jacobi in 55 collected cases found 5 to be congenital. Paul found 2 in stillbirths. Rare cases in which the tumor has been of sufficient size to obstruct labor have been reported (Porter and Carter). From the chart it is at once apparent that mixed tumors are quite rare after the age of 15 years. Hence it may be seen that these tumors occur essentially during early childhood.

Clinical Picture.—The symptomatology as presented in children is practically opposite to that in adults. The senior author in a previous publication *

* Hinman: Early Diagnosis of Renal Tumor. Surg., Gyn. and Obs., 1917, vol. xxiv, p. 669.

has shown that in adults, hæmaturia occurs as an initial symptom on the average in about 42 per cent. of cases and pain in 32 per cent. and tumor in 18 per cent. Eisendrath has noted that the three symptoms associated in various combinations occur in 78 to 80 per cent. of adult cases; that tumor but rarely was an initial symptom. In children the symptomatology is reversed and has a most insidious onset. The child may be perfectly healthy and well nourished at first. Tumor is nearly always the initial symptom. Occasionally diarrhœa, gastro-intestinal disturbances and emaciation may call attention to the presence of a tumor but only after physical examination. These tumors are painless as evidenced by the lack of complaints on the part of children. If present, it is usually of the dull aching type due to pressure on the intercostal or lumbar nerves. Colicky pain has occurred when due to the passing of a clot down the ureter. The growth of the tumor at first is slow but soon becomes rapid, so that it is not uncommon to see them assume large proportions in a period of weeks. It is during this period that

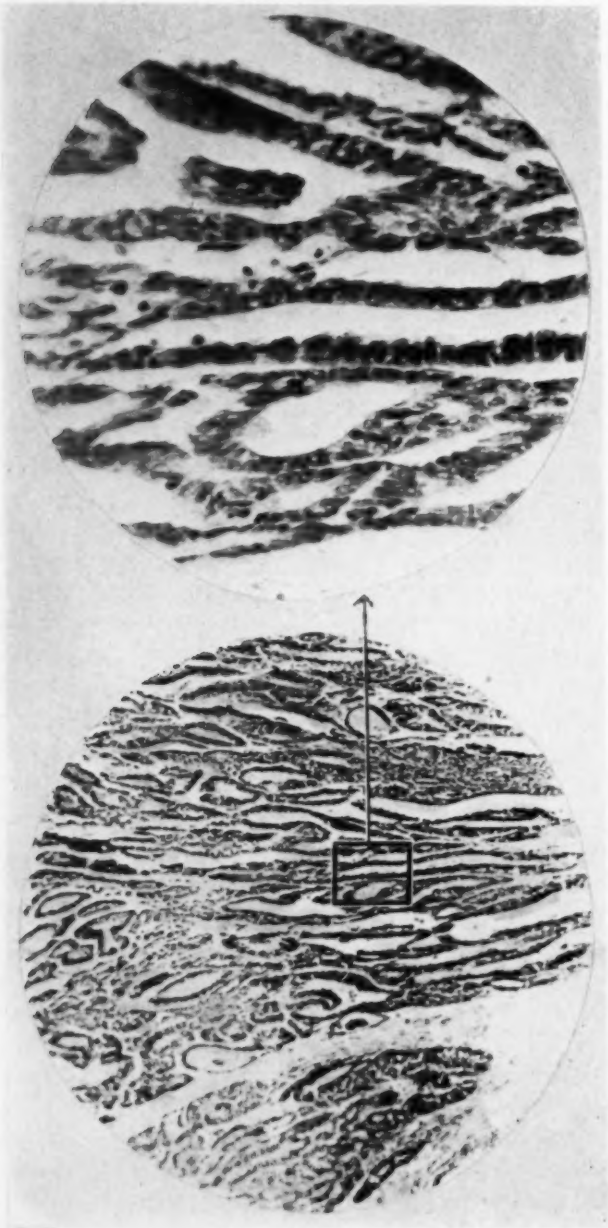

FIG. 5.—Microphotographs (low and high power) showing the embryonic tubular formation of the tumor. The cell types approach very closely those found in the embryonic renal blastema.

Fraser has suggested that the tumor changes from a slow growing adenomatous type to the rapidly growing sarcomatous type. If allowed to go on the tumor becomes of such immensity as to interfere with the normal functions of life.

Hæmaturia but very rarely is the initial symptom and is of rare occurrence at any stage of the disease. Walker in a series of 90 cases found tumor to be the initial symptom in 38 cases (42 per cent.); pain in 14 cases (15 per cent.); general weakness in 10 cases (11 per cent.); vomiting in 8 cases (8.8 per cent.); icterus in 2 cases (2.2 per cent.); diarrhœa, constipation, ascites and cough, one each. Albarran and Imbert noted tumor as an initial symptom in 71 per cent., pain in 20 per cent. and hæmaturia in only 5 per cent. Imbert found pain the initial symptom in 20 per cent., while Watson found it in 7 per cent., it being present at some time of the disease in 20 per cent.; in 9 per cent. it was noted that no pain was present at any time. Mixter, also, found hæmaturia but twice in 27 cases and microscopically in 6. Fraser reports a case in which there was a short period of hæmaturia about one year before the presence of tumor. Monsarrat does not believe that hæmaturia is as rare as is generally believed. He quotes Walker's 42 per cent. and presents a collected series of cases in which hæmaturia was mentioned; he found it to be present in 11 cases (35 per cent.) and absent in 20 cases. The fact nevertheless has been borne out by the majority of authors that it is very rare as an initial symptom and rather uncommon at any stage of the disease.

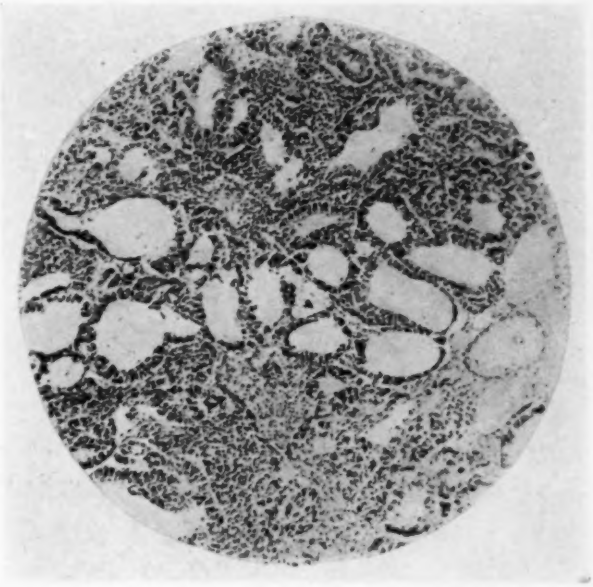

FIG. 6.—Microphotograph (low power) of a more cellular part of the tumor. It is characteristic of an embryonal adeno-carcinoma of renal blastema.

In the later stages of the disease the tumor is found growing to immense proportions. Associated with it are the signs of malignancy—anæmia, emaciation and general weakness. Signs of intra-abdominal pressure are seen in the swelling of the lower limbs, ascites, gastro-intestinal disturbances and enlargement of the superficial abdominal veins. In the very large cases diastasis of the recti muscles has been noted, with dyspnœa, cyanosis and pleural effusion where the thoracic cavity has been encroached upon.

The course of the disease is a very rapid one, the patient usually succumb-

Signs and Symptoms of Malignant Tumor of the Kidney in Children

	Initial %	Associated %
Tumor	42–71 Ave. 57	90
Pain	7–20 Ave. 14	20
General weakness	11	
Vomiting	8.8	
Icterus	2.2	
Diarrhœa, constipation, ascites	1 each	
Hæmaturia	Rare	5–35 Ave. 14

Note the reverse in the "Cardinal Trio" of symptoms from adults.

ing within a period of one year. Death is usually due to severe cachexia and occasionally metastases unless an intercurrent infection has not set in.

These tumors do not metastasize to the extent that other kidney tumors do. Walker found that in 142 mixed tumors metastases occurred in 55 (38 per cent.) to the following organs:

	Cases		Cases
Liver and lungs	11	Liver	4
Opposite kidney	11	Portal vein	1
Retroperitoneal glands	10	Diaphragm	1
Mesenteric glands	6	Scrotum	1
Vena cava	6	Bladder	1
Pleura	3		

Small intestines, colon and adrenals were also involved by direct extension.

Watson found metastases in 21 per cent. and in the following organs:

	Cases		Cases
Lungs	9	Vena cava	2
Liver	7	Axillary glands	1
Peritoneum	5	Bowel	2
Dura mater	1	Retroperitoneal glands	2
Scrotum	1	Mediastinal glands	1
Iliac fossa	1	Mesentery	1

From these tables it is apparent that when metastases occur they do so chiefly through the blood channels, involving the lungs and liver most usually and to an equal degree.

Diagnosis.—The attempt to make an early diagnosis in this disease is a difficult one for various reasons. The onset is usually insidious and one without any premonitory symptoms. As has been pointed out, tumor is usually the first symptom. The abdomen in infants and young children is quite apt to be somewhat protuberant, thereby tending to mask any early manifestation of the tumor. At this stage it may only be discovered by accidental palpation of the abdomen. Usually it is too late when the tumor can be palpated. Porter and Carter have called attention to the early appearance of a fullness at the costovertebral angle of the affected side. Gentle ballottement at the

costovertebral space is of importance. The firm but gentle intermittent pressure of the finger tips applied here will usually sense any of these enlargements.

The urine usually shows but little. Hæmaturia is not a feature. Pyuria associated with albumin and casts has been found at times, while it is not unusual to have practically negative findings as in our case.

Cachexia and anorexia are important signs but occur too late. Fever has been found in many of these cases.

That diagnosis of the urinary tract in children can be put upon a sounder basis by complete urological investigation has already been shown in previous publications.† The information received from differential kidney studies, microscopically and functionally, as well as by pyelography yields valuable data. That this can be carried out in the very young is well illustrated in Deming's case. The accompanying illustrations (Fig. 16) show the type of renal pelvic deformities associated with the mixed type of tumor. In some respects it is not unlike those found in the adult, namely, the process is one of encroachment upon the renal pelvis. The contour of the pelvis may have been completely destroyed and marked deformity or displacement of the ureter have occurred as is shown in our case.

FIG. 7.—Microphotograph (high power) of tumor showing the structure of the tubular elements. Compare with Fig. 8.

The presence of a large tumor in the lumbar region in childhood, especially if of rapid growth and associated with anæmia and cachexia, should always make one suspicious of a renal tumor. It usually begins in a lateral position. Air injection of the colon may be of considerable help in determining the position of the tumor.

There are several other conditions that present themselves for differential diagnosis. Mixter has called attention to a class of perirenal growths, the neurocytoma or neuroblastoma, which are considered as being derived from adrenal rests. He found 5 in his series of 27 cases. They can only be differentiated from the true kidney tumors by certain characteristics of the

† Hinman, F.: The Cystoscopic Study of Urologic Conditions in Children. Am. Jour. Dis. Children, 1919, vol. xvii, p. 305. Multiple Renal and Ureteral Stones in an Infant of Eleven Months. J. A. M. A., 1921, vol. lxxvi, p. 237.

metastases. There is the one type which metastasizes most rapidly and diffusely and yet the primary growth may be so small as to be overlooked. A case is cited in a two months' old child (Mixter) in whom there were multiple tumors of the buttocks, liver and forehead while the primary tumor in the adrenal was only the size of a walnut and only demonstrated at autopsy. The other type of neurocytoma grows to a large size without any evidence of metastases and cannot be differentiated clinically from the mixed tumor of the kidney except by direct pathological examination.

New growths of the retroperitoneal glands may occasionally cause confusion. Kidney tumors appear more laterally placed while the glands may be more central in position with an area of surrounding resonance.

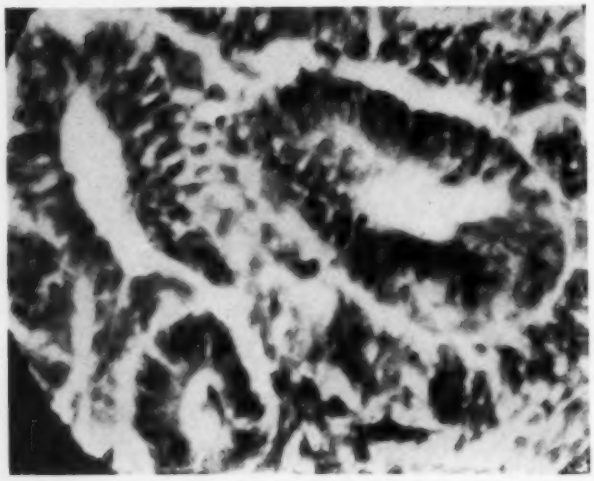

FIG. 8.—Microphotograph (high power) of the tubular elements in the embryonic kidney of a 20 mm. human fœtus. Compare with Fig. 7.

Splenic enlargements are encountered. These are usually due to the various leukæmias, malaria or lues. Careful blood studies are therefore essential. The anterior border of the spleen is sharp and there is usually no resonance over its anterior surface. Inflation of the large bowel may help in ruling it out. Splenic tumors also may have an area of resonance between the medial border of the tumor and the spinal column.

Tumors of the liver in children are exceedingly rare. Even the presence of jaundice may not be a point of differentiation since it must not be forgotten that the kidney tumors may grow to such proportions as to obstruct the bile ducts. The anterior border of liver tumors is easily felt and quite distinctive.

Hydronephrosis is of rare occurrence in children. It is slow in its development and never reaches the size of kidney tumors.

Renal tuberculosis does not reach the size of these tumors and presents usually characteristic urinary findings.

Tuberculous peritonitis may offer some difficulty but it can be ruled out by general signs and symptoms of the disease as well as a suggestive history, and the characteristic elongated tumor mass in the abdomen in transverse position.

Ovarian conditions and Wolffian body cysts are too rare for serious consideration.

Prognosis and Treatment.—The treatment for mixed tumors of the kidney is early radical excision. We will not enter into the relative advantages of either the abdominal or lumbar route. Albarran and Imbert found in 101 cases that their mortalities were: abdominal route 26 per cent.; lumbar route, 28 per cent. That these operations can be performed in very young patients under local anæsthesia has been shown (Deming).

The prognosis of this disease is indeed a very dark one. The primary mortality from operation with that due to recurrences is very high, it having been placed by some as high as 93 per cent.

Albarran and Imbert in analyzing statistics between 1876 and 1902 found

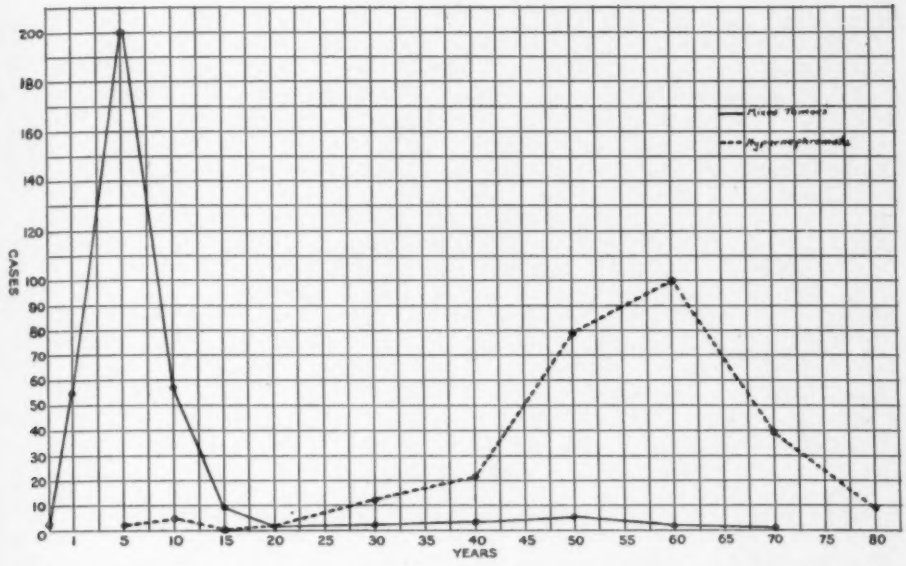

FIG. 9.—Chart showing age incidence of "mixed tumors" and hypernephromata of the kidney. Note that the "mixed tumors" occur chiefly in childhood and hypernephromata in old age. Based on 341 "mixed tumors" and 267 hypernephromata.

that the operative mortality dropped from 52 per cent. to 21–25 per cent. It seems never to have gotten less than this except in isolated series and usually is higher. The following are a few quoted from the literature: Walker, 36.4 per cent. in 74 cases; Lewi (Monsarrat), 28 per cent. in 62 cases; Albarran, 30 per cent. in 97 cases; Heresco (Monsarrat), 17 per cent. in 53 cases; Shannon, 38 per cent.; Concetti (Jacobi), 40 per cent.; Hyman, 12½ per cent. in 8 cases; Loughnane, 8 per cent. in 13 cases; Mixter, 35 per cent, in 14 nephrectomies and 44 per cent. in 9 explorations. The general average is 28.5 per cent. This high primary mortality must undoubtedly be due to the poor condition these patients are in at the time of operation. Monsarrat, in his collected series, has pointed out that the younger patients seem to tolerate operation somewhat better; thus, of 23 cases that were under two years of age, 4 died (17 per cent.).

The rate of recurrence in the surviving cases is very high. In Monsarrat's series of 104 collected cases 77 (74 per cent.) survived operation; of these only 58 have had

any follow-up; of these, 40 (51 per cent.) died within a few months, leaving 18 (23 per cent.) living and well on the average of 8½ months post-operative. Concetti (Jacobi) found that of the 60 per cent. surviving operation, 45 per cent. died with recurrences. Loughnane in 35 cases collected from London hospitals found recurrences in 80 per cent., 70 per cent. of which occurred within one year. Hyman, in 7 cases (out of 8) surviving operation found that 5 died within 1 year, 4 of which occurred during the first 6 months. In Mixter's 9 surviving cases (out of 14) all except one died of recurrence in from 4 months to 1½ years. From these statistics it is at once apparent that the ultimate mortality of this very malignant disease is between 80 and 90 per cent. Shannon states that the ultimate mortality is 94 per cent. and 5 per cent. cures. Concetti places the cures at 7 per cent. Bland-Sutton puts it at 5 per cent. It has been pointed out that the very

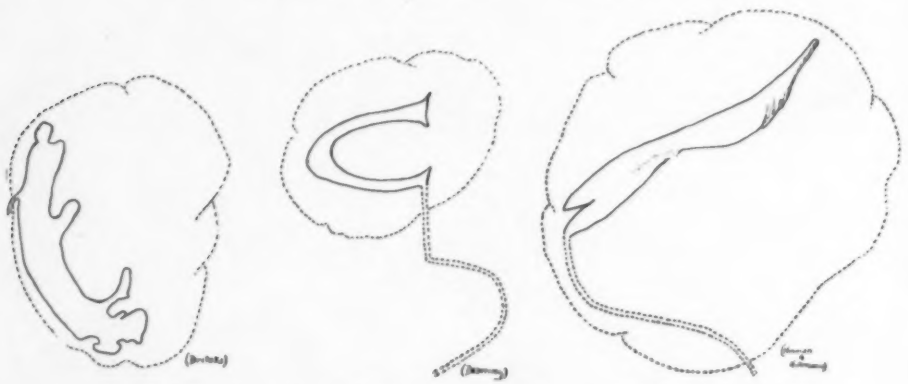

FIG. 10.—Drawings showing pelvic deformities of "mixed tumors" of the kidney in children as demonstrated by pyelography.

young patients, especially if under the age of two years, usually survive if they live one year or longer post-operative. There are some cures on record (Mixter, Hyman, Malcolm (Bland-Sutton), Abbe, etc.). Of these the most interesting is that of Abbe's. A 7½ pound solid tumor (pathological report—"rhabdomyosarcoma") was removed by partial nephrectomy from a twelve months' child in 1892. The patient was reported as living and well and demonstrated to the New York Surgical Society in 1912—20 years since the operation.

No systematic study of the effect of the Röntgen-ray on these mixed tumors of the kidney appears in the literature. Friedlander in 1916 tried this method of treatment upon a four-year-old child with an inoperable tumor of the kidney. After seven treatments in seven to ten-day intervals the tumor decreased markedly in size and the child gained in weight and strength. A few months later it was noted that the patient was again becoming listless and the tumor larger. The patient contracted measles and died with a bronchopneumonia. Grisanti very recently reported a case in an eleven-year-old girl who at operation revealed a kidney tumor (sarcoma) so adherent as to make its removal impossible. The organ was brought to the surface and given thorough Röntgen-ray treatment at two sittings, through the laparotomy incision and a third after it had healed. By the end of the second month no tumor could be felt. It may possibly be that the course in the case may be similar to that of Friedlander's case just cited. Mixter and, more recently,

Gage and Adams, have tried the Röntgen-ray on cases with post-operative recurrences but without avail.

In the treatment of these very malignant tumors we come against a peculiar paradox. The disease is one with an insidious onset, producing difficulties for an early diagnosis and yet to have a chance to cure, the diagnosis must be made very early and the extirpation complete.

Summary.—(1) The occurrence of renal tumor in children is 0.06 per cent. (1 in 1600); in adults 0.25 per cent. (1 in 400); in animals it has been found to average 0.02 per cent. (1 in 5000). The relative frequency of kidney tumors among tumors in general in children is 20.4 per cent. (1 in 5); in adults from 0.5 per cent. to 2 per cent.

The relative proportion of children to adults is 24 per cent. (1:4). It has been quoted as high as 33⅓ per cent. (Rohrer).

The relative frequency of mixed tumors and hypernephroma in general is 9.1 per cent. and 36 per cent., respectively, 60–80 per cent. being more correct for the latter.

Involvement as to side and sex is about equal; 4 per cent. are bilateral.

(2) Mixed tumors of the kidney are the renal growths of childhood, the greatest majority occurring within the first five years; but they may occur later in life or be present at birth.

(3) Three theories have been put forth as to pathogenesis: (*a*) that they are due to inclusions of the Wolffian body (Birch-Hirschfeld); (*b*) that aberrant cells from the myotome, sclerotome and mesenchyma are the explanatory factors (Wilms); (*c*) that they are descendant from the true embryonic kidney tissue or renal blastema and develop by a process of metaplasia (Busse, Muus, Ewing).

(4) The tumors may assume large proportions, the average, however, being about 1 to 4 pounds. Grossly they appear as solid opaque or cystic processes. Microscopically various types of tissue are found—embryonic proliferating tissue, glandular, myxomatous, bone and cartilage, smooth and striated muscle fibres, etc. The picture usually presented, however, is an embryonic one, dominated by either glandular or cellular tissue; if the former it is called embryonal adenocarcinoma, if the latter, embryonal adenosarcoma.

(5) The clinical picture is presented in usually the following order—abdominal tumor; presence or absence of hæmaturia or pain; anæmia, general weakness, anorexia and cachexia terminally; metastases either local or distant. Tumor nearly always is the initial symptom.

(6) The routine urological procedure can be used to advantage in children.

(7) Differential diagnosis is from neurocytomata tumors of retroperitoneal glands, spleen enlargement, tumors of the liver, hydronephrosis, renal tuberculosis, tuberculous peritonitis and ovarian conditions.

(8) The prognosis is a very poor one, the ultimate mortality after nephrectomy ranging from 80 per cent. to 90 per cent.

(9) The treatment is early diagnosis and radical excision. The use of the Röntgen-ray has given but very little encouragement.

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PAPILLARY EPITHELIOMA OF KIDNEY PELVIS

By Walter M. Jones, M.D.

and

Grayson L. Carroll, M.D.

of Saint Louis, Mo.

Stimulated to increased interest in tumors of the kidney by Scholl's [1] recent article, it was our good fortune to recently diagnose a papillary carcinoma in the upper portion of the pelvis of the kidney prior to operation.

Due to the small number of cases reported in the literature, we desire to place the following case on record in order to better establish the diagnostic signs and symptoms. Up to the present time fifty-one cases of papillary epithelioma of kidney pelvis have been reported, only thirteen of which were reported in American literature. Five of the American cases are from the Mayo Clinic.

No doubt the condition is much more common than the literature would indicate, as we know of three cases which have not been reported, namely: patients of C. E. Burford, of St. Louis, E. L. Keyes, of New York, and A. C. Gilbert, of Dallas, respectively. Those especially interested in the bibliography are referred to McCown's [2] article published in 1920.

Fig. 1.—Pyelogram of left kidney; superior and middle calyces absent.

Report of Case.—Register No. 2942; a deckhand, aged sixty-five years, white, married, Frenchman. Entered hospital, March 4, 1924, complaining of passing blood from the bladder, weakness, and pain in the left lumbar region radiating to the left groin. He stated that the trouble started two years ago with an attack of pain in the left side and the passing of blood instead of urine; coming on apparently without cause. The present attack started two weeks ago with the passing of blood, followed by weakness and pain. No history of cough, night-sweats, passing of gravel or stomach trouble. *Family history.*—Negative. Wife in good health. Patient a hard worker. No alcoholics or drugs. Chews tobacco moderately. No history of any serious illness or injury. Denies any venereal disease.

Physical Examination.—Patient is a poorly nourished and muscled elderly white man; pale, worried expression; dyspnœic upon slight exertion; weight 145 pounds.

height 68 inches. Scleræ slightly injected; pupils large, react to light and accommodation. Tonsils red. Teeth poor and caries present. Thorax negative. Abdomen: No tumor masses palpable. Spleen, kidneys, and liver not palpable. Stomach tympany increased in size by percussion. Nervous system: Negative. Extremities: Normal. Genito-urinary system: No scars on penis. Testicles and epididymii normal. Prostate enlarged, hard, round.

Cystoscopic Examination.—March 8, 1924 instrument passed with ease. Bladder of good capacity; found filled with bloody urine. Sphincter margin slightly irregular; trigone elevated; bladder wall showed many trabeculations. There was no evidence of papillomatous growths or tumors. The right ureteral orifice was small and pale. Ureteral catheter passed with difficulty due to spasm. Spurts of blood were seen to come from the left ureteral orifice. Left ureter catheterized with ease. Specimens of urine collected. Pelvi injected with 20 per cent. solution of sodium bromide and röntgenograms taken. Laboratory reported catheterized urine from the right kidney, negative. Left kidney, red blood cells many. No pus. Staphylococci on culture (probably contamination, in absence of pus). Pyelogram of the left kidney (Fig. 1) shows absence of the superior and middle calyces and upper portion of the pelvis. The inferior calyx is normal, showing the minor calyces.

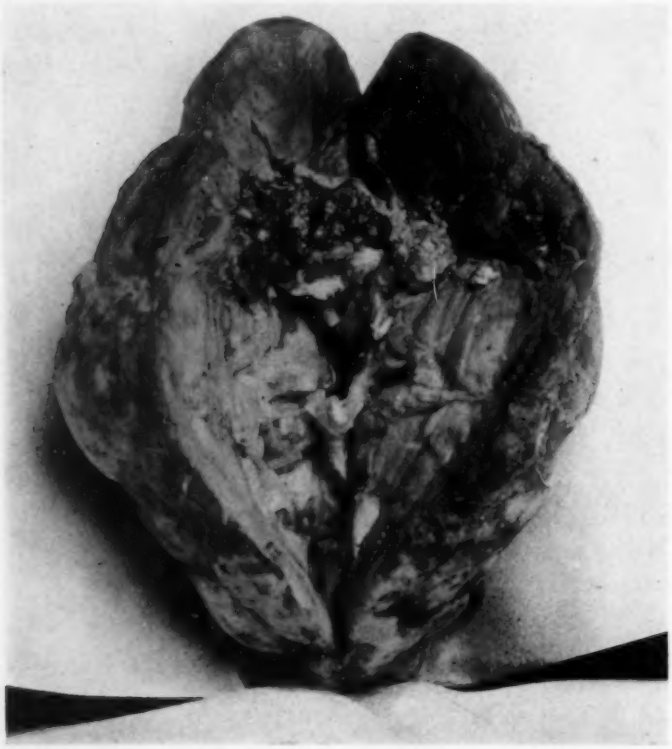

FIG. 2.—Kidney split open after removal showing growth.

March 14, 1924.—Patient complains of increase of pain in the left costo-vertebral angle, and the urine, which has been bloody continuously since admission, is entirely clear. This demonstrated very nicely the complete obstruction of the left ureter by blood clot.

March 15, 1924.—Cystoscopic examination was repeated March 15 to determine the function of the right kidney. This examination revealed a ropy blood clot, which was an exact mold of the ureter and was about 6 cm. in length protruding from the left ureteral orifice and curled within the bladder. No urine was seen to flow from this occluded ureter and the peristolic waves were absent. A large Garceau catheter was inserted into the right ureter and 1 c.c. phenolsulphonthalein injected intravenously. The dye from the right ureter appeared in 4½ minutes. It excreted 25 per cent. for first fifteen minutes 20 per cent. for second fifteen minutes. The bladder urine collected after one-half hour showed no dye because left ureter was occluded by blood clot.

March 25, 1924.—A diagnosis of papillary epithelioma of the left renal pelvis was made. Nephrectomy by Doctor Jones. Usual Mayo incision exposing left kidney. Fatty capsule somewhat adherent. Kidney delivered and split open exposing the growth. (Fig. 2). Pedicle doubly clamped; kidney removed and vessels ligated. Incision closed. Kidney was smaller than normal and the surface showed a hemorrhagic mottling. The ureter was apparently normal. The upper calyx was completely filled with a papillomatous growth.

Patient had an uneventful convalescence until evening of April 4, 1924 when he had a chill and his temperature jumped to 103.5° F. Cough and bloody expectoration and the left lower lobe showed definite involvement. After three or four days patient began to improve and went on to recovery. When discharged on May 12, 1924 he had gained 40 pounds. Blood count was normal. Patient stated that he felt perfectly well.

Microscopic examination of section of tumor growth reported by Dr. D. L. Harris, is as follows: The specimen consists of a sessile papillary out-growth from the upper pole of the pelvis of the kidney. Microscopic examination of sections show the growth to be made up of epithelial cells growing out upon branching connective tissue stalks. In the deeper lying portions the cells are elongated, but towards the surface they are oval or polyhedral. Mitotic figures are fairly numerous. Intra-cellular fibriles are easily seen in the cells near the surface. Diagnosis: Papillary carcinoma.

Laboratory Report.—March 19, 1924, red blood count 3,240,000, hæmoglobin, 65 per cent. May 7, 1924, (44 days after operation). Red blood count 4,200,000. Hæmoglobin, 75 per cent. White blood count 6480.

Blood Wassermann.—March 5, 1924: Positive double plus.

Blood Wassermann.—March 13, 1924: Positive plus.

Urine.—March 3, 1924: Alkaline gross blood; specific gravity, 1038. Albumin trace. Squamous epithelial cells present. Few granular casts.

Urine.—March 8, 1924: Albumen plus sugar absent. Granular casts present.

Urine.—March 20, 1924: Albumen plus. Granular casts and few pus cells.

Urine.—April 8, 1924: Acid, specific gravity 1022. Albumin, sugar, casts, and pus cells absent.

Guinea pig injected with catheterized urine left kidney. Autopsy showed no evidence of tuberculosis.

Comment.—The chief diagnostic findings in the case were persistent hæmaturia with weakness and pain in the left lumbar region radiating to groin, the pyelogram showing a normal lower calyx and absence of the two upper calyces. (The return flow of the opaque solution alongside the catheter showed that sufficient fluid had been injected.)

Differential Diagnosis.—The absence of pus (in catheterized specimen) and bladder symptoms, and the absence of any destruction seen in the pyelogram excluded tuberculosis. A hypernephroma which is causing such marked bleeding can usually be palpated externally, and the pyelogram presents a spider-web-like appearance rather than a filling defect. Syphillis was considered because of the two plus Wassermann reactions, but the absence of other luetic lesions, the profuse bleeding, and the pyelogram was evidence against it. We consider the prognosis of this case favorable.

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SQUAMOUS-CELL TUMORS OF THE RENAL PELVIS*

By Albert J. Scholl, M.D.

of Rochester, Minn.

resident surgeon, st. mary's hospital, mayo clinic

and

Gordon S. Foulds, M.B. (Tor.)

fellow in urology, the mayo foundation

Squamous-cell changes in the urinary tract, as in the mouth, gall-bladder and other organs, generally form in response to repeated mechanical trauma or to tedious infections. All parts of the urinary tract are subject to this proliferation of epithelium to a condition resembling skin. Cedercreutz, Dittle and Kaufmann describe its occurrence in both benign and malignant stages in the urethra; Albarran, Hallé, and Kretschmer in the bladder; and Kischensky, Scheel, Cumming, and others in the renal pelvis. In the urethra and bladder epithelial changes may follow years of recurrent infection and scar formations; for example, Judd operated on a case of squamous-cell tumor of the anterior urethra which had followed twenty years of urethral infection and instrumental manipulations. Trzebicky reported a case of squamous-cell carcinoma developing on a traumatic stricture of ten years duration. In two cases treated at the Mayo Clinic squamous-cell carcinoma of the bladder followed periods of cystitis which commenced with the trauma of childbirth, twenty-eight and twenty-nine years before. Morris reported a case of squamous-cell tumor of the lower end of the ureter which for many years had been the resting place of calculi. In the renal pelvis similar epidermoid changes occur. Small areas of hyalinization and squamous-cell changes are not infrequently seen in hydronephrotic sacs. More extensive epidermoid changes occur in cases of long-standing renal infection, either with or without stones, but long duration of infection is not essential in all cases, for these changes at times result in association with short periods of severe infection (Figs. 1 and 2). In one case, in a man aged twenty-six years, a nephrectomy was performed at the Mayo Clinic after only nine months of severe pyelonephritis. The renal pelvis contained a number of raised, wrinkled, grayish-white plaques, 1 to 2 cm. in diameter; histologic examination revealed squamous-cell changes. Orth, Beselin, Hallé, and Kretschmer, have all reported cases of leukoplakia associated with tuberculous pyelitis. Not all cases, however, are the result of infection or long-continued irritation. Wendel reports a case in which there was no inflammation. Leber notes a case in an infant of four months; similar changes were also noted in the infant's eye. Lecène, Klug and Grauhan attribute the formation of leukoplakia to developmental changes. Richey holds that metaplasia occurs both as a physiologic process and as a

* This work was done under the direction of Dr. W. F. Braasch, Section on Urology, Mayo Clinic, Rochester, Minnesota.

result of certain pathologic conditions, the latter involving repeated trauma to a tissue over an extended period of time.

Not infrequently in the renal pelvis, as in the urethra and bladder, the same factor which produces the metaplasia continues its action until malignant changes develop. Albarran holds that most squamous-cell growths are preceded by leukoplakia. Besenbruch reported squamous-cell carcinoma developing on a case of tuberculous pyelitis. Spiess considered nineteen of 136 cases collected by him as squamous-cell carcinomas; seventeen of forty-three cases of non-papillary tumors of the renal pelvis collected by Kretschmer were considered as epidermoid growth. The tissues adjacent to the malignancy often showed epidermoid changes. Aschner described a case of squamous-cell carcinoma arising at the ureteropelvic juncture in association with leukoplakia of the renal pelvis.

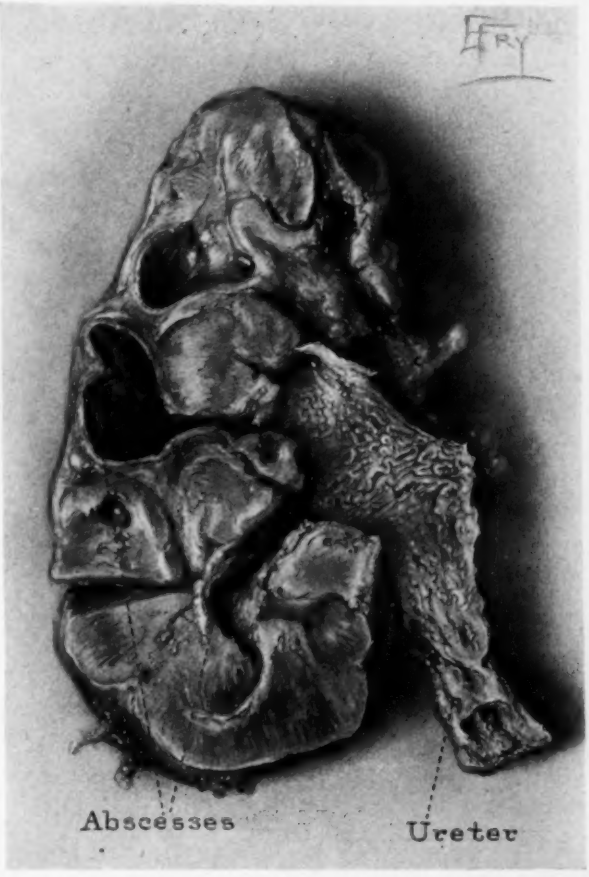

FIG. 1.—Leucoplakia of the pelvis of a markedly infected kidney. Area of epidermization is white, thickened and involves the whole pelvis.

Symptoms.—Squamous-cell tumors of the renal pelvis are comparatively symptomless. When obstruction occurs, it is from a gradual slow occlusion and is almost painless, at times causing tremendous dilatation of the kidney pelvis. In contrast to papillary tumors, the squamous-cell carcinomas rarely bleed. A similar slow, painless occlusion and pelvic distention occurs with squamous-cell growths of the ureter. In a case reported by Rundle a hydronephrosis of two and a half litres resulted from a squamous-cell epithelioma which blocked the lower ureter; there had been no pain or renal colic. Squamous-cell epitheliomas of the renal pelvis may have a long-standing, possibly premalignant history of trauma and infection, as occurs in squamous-cell growths of the urinary bladder. Oraison reports the case of a woman, aged fifty years, whose symptoms of renal trouble started with trauma

at twenty-four. At operation a squamous-cell tumor of the renal pelvis was found.

Similar to infection and stone formation, tumor growth is often seen in abnormally developed, poorly drained kidneys. Cases of squamous-cell carcinoma associated with stone in horseshoe kidneys have been reported by Wulff and Primrose.

Pathology.—There are two types of squamous-cell tumors arising in the renal pelvis: in the first, the renal parenchyma is invaded early, the kidney is solid and compact, and the parenchymal tissue becomes completely replaced by carcinoma and irregular masses of fibrosis: in the second, the growth is confined to the renal pelvis, the kidney is extremely large and hydronephrotic with a pressure atrophy of most of the renal tissue.

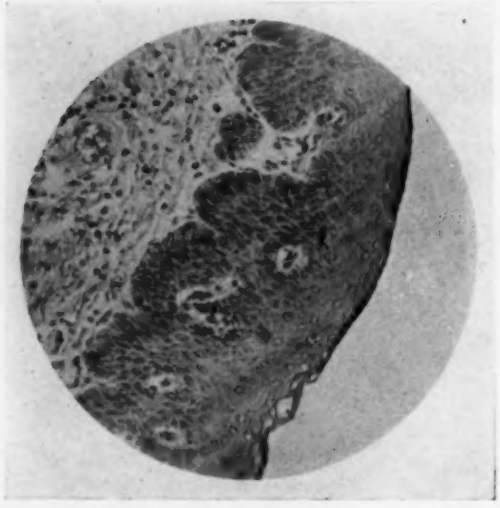

FIG. 2.—(Case A75112.) Leucoplakia of the pelvis of the kidney.

In the first type, the carcinoma at times extends to the pedicle and neighboring glands; the pelvis is thickened and fixed by the tumor growth, and the malignancy is not infrequently associated with stones. This same association of squamous-cell tumors and calculi holds true in other organs. Nicholson collected sixteen cases of squamous-cell carcinoma of the gall-bladder; fifteen had gall-stones. It is possible that in certain cases the development of the carcinoma of the renal pelvis may precede the formation of stone. Hallé maintains that the metaplasia does not result from the irritation of the stone, but that the epidermization and calculi both result from the same chronic inflammation. In the renal pelvis the stones are at times extremely large, and of the staghorn earthy-phosphate type. Kaufmann reported a case in which the stone weighed 93 gm. A similar case was noted by Oraison, in which the patient had attacks of renal colic for twenty-eight years; the stone weighed 107 gm. Wells and Kundrat also report cases of squamous-cell tumors associated with large branching stones. Of eleven collected cases considered by Wells as definite squamous-cell carcinomas, six had stones. The long duration of symptoms of calculi and infection in most cases indicates that the presence of stone precedes the development of carcinoma by many years. The malignant changes set in later, possibly as a result of long-continued trauma, either inflammatory, mechanical, or both. In an occasional case there is a definite increase in the severity of the symptoms, suggestive of the onset of malignancy. In 108 cases of associated renal calculi and malignancy, collected by Martin and Mertz,

the symptoms of stone averaged nineteen years in duration; the symptoms suggestive of malignancy averaged about five months.

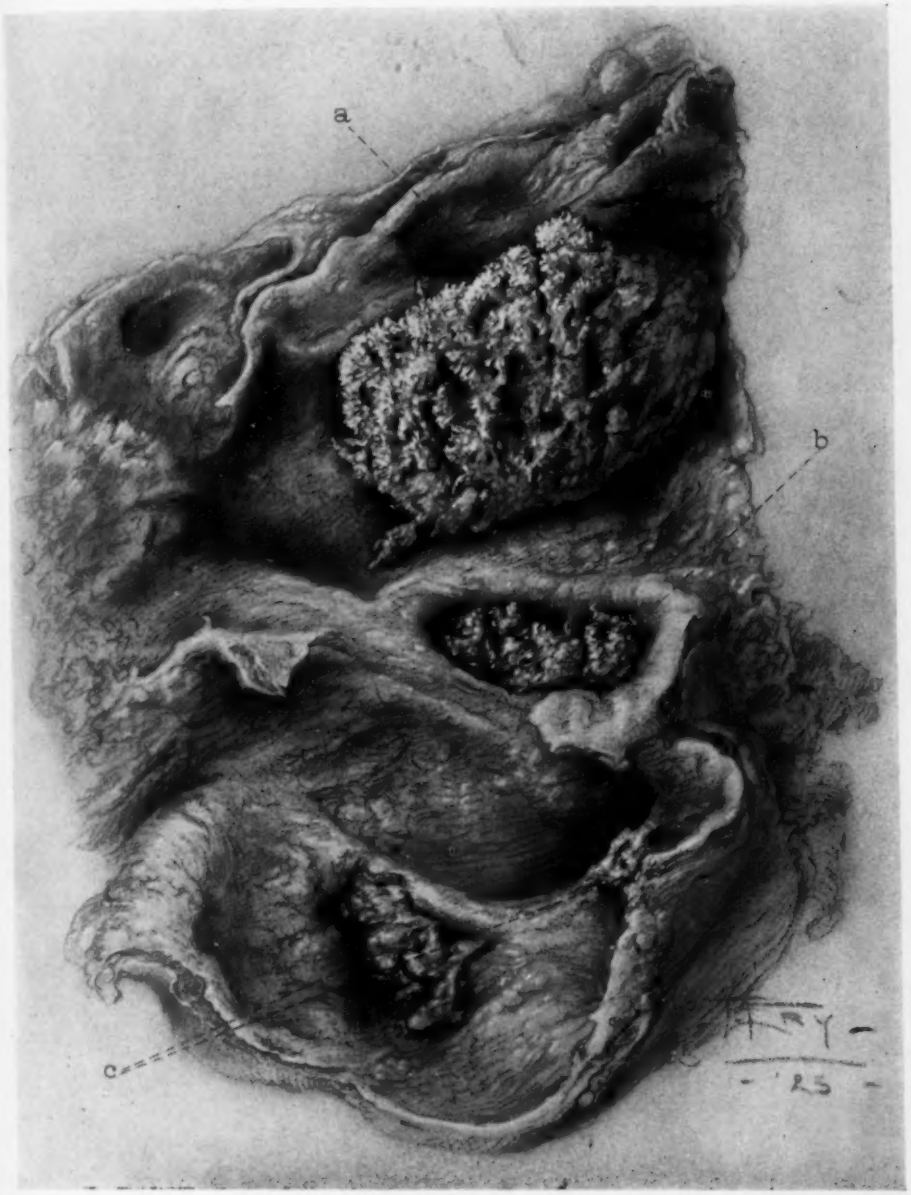

FIG. 3.—Portion of thickened sacculated pelvis of kidney, which is covered with papillomas and squamous-cell tumors. (a) and (b) grossly papillomatous masses, (c) flat tumors; all are composed of squamous-cell carcinoma.

The majority of stones found in cases of carcinoma of the renal pelvis are rough and irregular. Because of infection and ulceration of the pelvic mucosa, it is occasionally impossible to find any tissue adjacent to the pelvic wall suitable

for histologic examination. As the growth spreads throughout the kidney, the cells change to a more irregular, rapidly growing type and detach themselves from the original, identifying, epidermoid masses. In certain instances, the varying transition stages may be traced from a definite squamous-cell growth to masses containing only large irregular epithelial cells, loosely bound together, with little hyalinization or epithelial whorl formation. It is quite probable that the majority of the solid type of carcinomas of the kidney, the carcinoma simplex, occurring in association with infection and large pelvic stones, originate from metaplastic pelvic epithelium.

FIG. 4.—(Case A400589.) Hyalinization and squamous-cell formation from tumor of renal pelvis.

In the second type of squamous-cell carcinoma arising in the renal pelvis, there are numerous tumor masses on the thickened dilated pelvic wall, some small and papillomatous, others large, bulky and at times smooth-surfaced. This type of growth causes comparatively few localizing symptoms. The insidious onset and lack of definite symptoms occurring with squamous-cell tumors of the urinary bladder also occur with this type of growth in the renal pelvis. The ureter is occluded, and there is a complete atrophic destruction of the parenchymal tissue. Attention may only be directed to the condition by the finding of a large cystic abdominal mass. There is at times extreme hyalinization and epithelial desquamation of the type described by Rokitansky as cholesteatoma; Luys and Chenot and Ewing described cases of this type. In a few instances papillary tumors of a moderate degree of malignancy are found associated with squamous-cell lesions. The primary growth is possibly papillomatous in type, as small areas of hyalinization and epithelial whorl formation are often seen in papillomas. In one case a definite leukoplakia was found in association with a villous pyelitis; this case is of interest as it suggests a transition stage from an infectious to a malignant tumor, having both

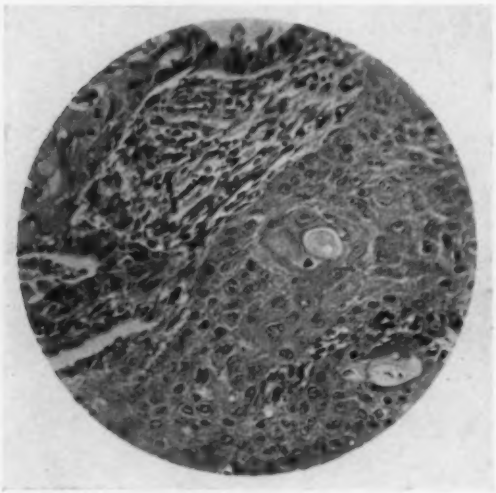

FIG. 5.—(Case A320171.) Extensive wedge of squamous-cell carcinoma with small area of hyalinization.

papillary and squamous characteristics. Battle also describes squamous changes in a small villous growth, and Rohde, Scheel, and Menetrier and Martinez describe combinations of papilloma and squamous-cell epithelium.

Metastasis.—Metastasis occurs early and extensively in both types of squamous-cell growth. The cases reported by Kischensky, Menetrier and Martinez, Scheel and Ewing had metastasis to the liver, lungs and bones. In an occasional case extension occurs through the large blood-vessels similar to the mode of extension in adenocarcinomas (hypernephromas); Taddei noted an occlusion of the vena cava, the carcinoma having grown through the renal vein. In the case reported by Wells the tumor had grown extensively into the perirenal tissues. The metastatic growths are usually of epidermoid structure, even though the original growth contains both papillary and squamous-cell masses as in Scheel's case. The same extensive metastasis also occurs in squamous-cell carcinoma of the ureter. In the bladder, metastasis occurs only rarely with epidermoid carcinomas; death usually results from the local condition before extension occurs. As brought out by Braasch in regard to renal tumors in general, extensive metastases may be present when the renal growth is so small that it cannot be palpated clinically.

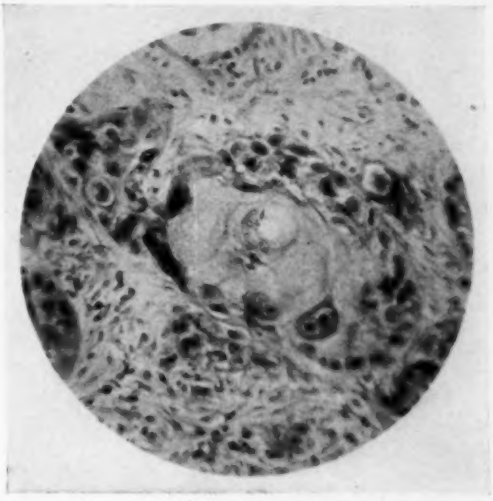

FIG. 6.—(Case A23253.) Epithelial pearl formation from squamous-cell carcinoma of the renal pelvis.

Prognosis.—Squamous-cell tumors of the renal pelvis offer the patient a very poor prognosis, and in this respect are comparable to histologically similar tumors occurring in the urinary bladder. Five of six patients with squamous-cell tumors of the urinary bladder examined at the Mayo Clinic died shortly after the disease had reached a stage requiring treatment. Because of the comparative absence of symptoms, treatment is generally not considered while the growth is still in the early stages. In a series of cases reported by Kretschmer, there were eight nephrectomies for squamous-cell carcinoma of the renal pelvis; five patients died at operation or shortly afterward, and the remaining three developed extensive metastasis not long after the operation.

Mayo Clinic Series.—From 1907 to 1922, five cases of squamous-cell tumor of the renal pelvis were treated at the Mayo Clinic.

REPORT OF CASES

CASE I.—(A 400,589.) A man aged sixty-two years, came to the Clinic August 7, 1922, complaining of a tumor in the right side of the abdomen "about the size of his fist." This was first noticed four months prior to the patient's registration at the Clinic,

and had increased rapidly in size. For the past three years he had moderate frequency of urination. Eighteen months before, he had had a moderate intermittent hæmaturia, but none for the past year. He had not lost weight, and his general condition was good. On examination the mass was found to be very large, filling the right side of the abdomen; it was soft, rounded and painful on palpation. The urine was not abnormal, and the phenolsulphonephthalein return was 40 per cent.; the blood urea content and hæmoglobin were normal. Röntgenographic examination of the kidneys, ureters and bladder was negative. Cystoscopic examination revealed a normal bladder mucosa; there was hypersecretion from the left kidney; the right ureteral opening was small; no secretion was seen in ten minutes' observation, and an obstruction impassable to the ureteral catheter was found 20 cm. from the bladder.

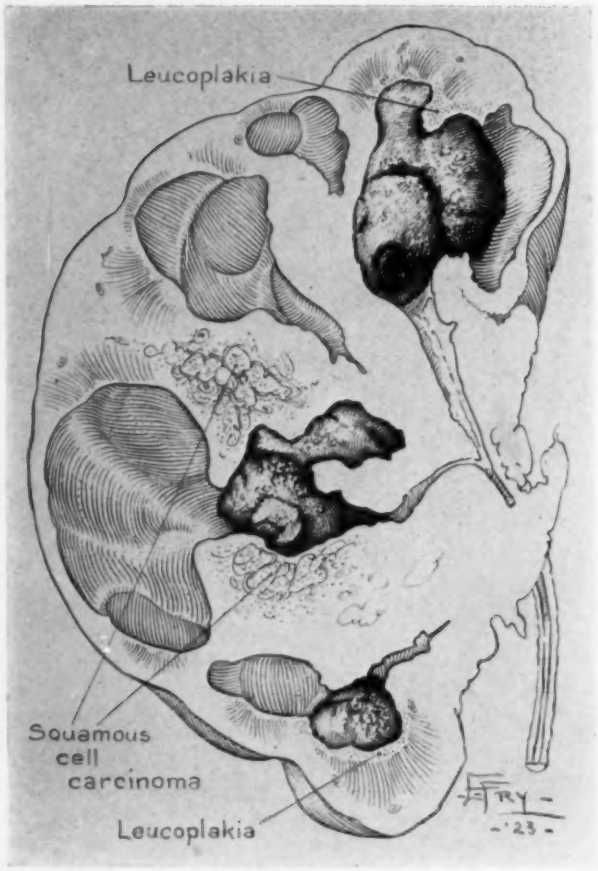

FIG. 7.—Squamous-cell tumor of the renal pelvis infiltrating entire kidney. Areas of leucoplakia surround fragments of stone.

At operation, through a transperitoneal incision, the tumor was found to be cystic and irregular, and firmly adherent to all the surrounding tissues. In freeing the adhesions the renal mass was ruptured, and the remaining shell then removed. The patient was in good condition at the end of the operation. The convalescence was uneventful, save for a reopening of the wound which was successfully resutured.

Pathology.—The renal mass was tremendously dilated and there was complete atrophy of the parenchymal tissue. The pelvis was greatly thickened, sacculated, and surfaced with many irregular tumors varying in size from 1 to 8 cm. in diameter. These tumors were of two types; some, especially the smaller ones, were loose and papillomatous, others were hard and smooth-surfaced or covered with papillomatous protrusions, while the intervening mucosa in many areas was thickened, wrinkled and gray in color. There were a number of dilated pouches extending from the distended pelvis, and probably corresponding to the site of the original calices, some of which were from 6 to 8 cm. in diameter, and had the same wrinkled epidermoid appearance as the pelvis (Fig. 3). A number of irregularly rounded stones, about 1 cm. in diameter, were found loose in the pelvis. The solid masses were very friable, similar to the extensively hyalinized areas of squamous-cell growth occurring in the bladder. Histologically, the hard tumors were squamous-cell carcinoma of a high degree of malignancy (Fig. 4. There were extensive masses and large circular plugs of cells undergoing various stages of hyalinization and epithelial whorl formation. In many areas the cells were large,

with clear-cut outlines, containing one or more deeply stained nucleoli. Many large, atypical mitotic figures were seen. The process was a much more rapid growth than is usually found in similar tumors located in the urinary bladder. In many areas remnants of altered papillæ and the cellular arrangement indicated the probable papillary origin, and this was much more evident in the grossly papillomatous type of growth. In no area was the growth found to penetrate through the pelvis, but the uninvolved mucosa of the pelvis and calices in many areas was undergoing definite epidermoid changes.

CASE II.—(A320,171.) Mrs. H. B. S., aged fifty-three years, came to the Clinic June 16, 1920, complaining of attacks of moderate abdominal pain, which had started nine months before. There was no nausea or vomiting, and at the onset the pain was on the right side; recently it had become more severe and localized in the lower abdomen. An appendectomy had been performed without relief.

The general physical examination was negative; the urine was not abnormal; the hæmoglobin was 67 per cent.; the phthalein return, 55 per cent. A röntgenogram of the urinary tract contained several indefinite shadows in the right kidney region. Cystoscopic examination revealed a chronic diffuse cystitis; the left ureteral opening was normal, and the secretion normal and clear; the right opening did not contract and the ureteral catheter met an impassable obstruction 20 cm. from the bladder; urine from the right ureter contained pus, and a pyelogram of this side revealed a rough irregular pelvic outline.

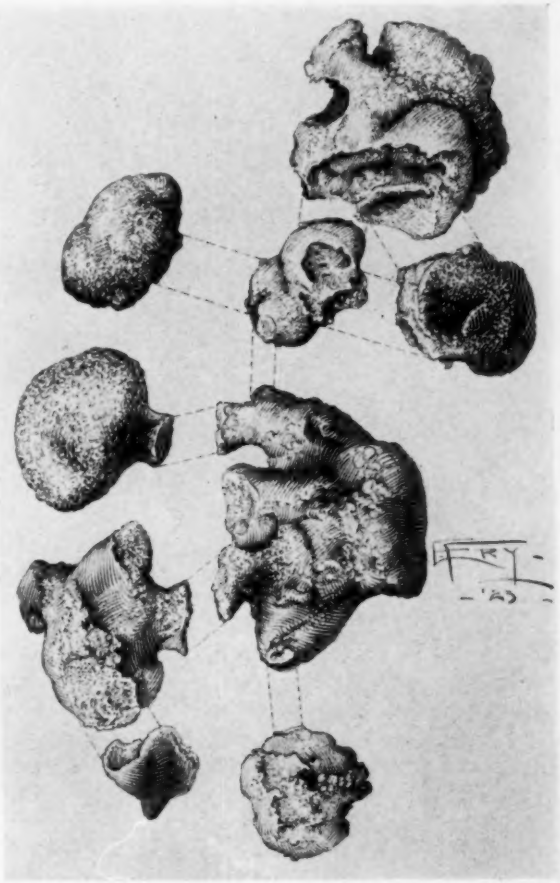

FIG. 8.—(Case A138795.) Squamous-cell tumor of the pelvis. Large irregular coraliform type of stone from the pelvis of a kidney.

June 22, 1920, a large, solid, firmly adherent kidney was removed through a right lateral incision, and extensive induration and œdema around the hilus was found to be present. The pedicle was not tied on account of the friability of the tissues; five forceps were clamped and left in place. The patient rallied well from the operation and the forceps were removed on the fifth day. On the eighth day she felt weak, had a subnormal temperature and gradually declined, dying on the eleventh day.

Pathology.—The kidney was about twice normal size, solid and fibrous, imparting a gritty sensation to the knife. On cut section the surface was board-like, with many interlacing bands of fibrous tissue throughout. The pelvis was fixed, and surrounded by solid malignant and fibrous tissues; it had an extensively desquamating surface from which bands of white radiated out into the surrounding mass. There was also an

extension along the renal vessels and out into the perirenal tissues. Histologically the invading tissue was found to be a squamous-cell epithelioma with evidence of extremely active malignant growth (Fig. 5). Near the pelvis there was extensive desquamation and hyalinization, but no papillary structures were found. In the parenchymal portion of the kidney the malignant cells were large, markedly irregular in size, stained deeply, and contained a great many mitotic figures. Only small areas of normal renal, parenchymal tissues remained. Malignant cells were found encircling moderately atrophic glomeruli and following the course of collecting tubules. In some areas the parenchymal tissues were found unchanged by the encroaching malignant cells, indicating a comparatively rapid and recent invasion. The squamous-cell changes were confined to the tissues adjacent to the pelvis.

Case III.—(A232,253.) J. T. R., a man aged fifty-four years, came to the Clinic May 6, 1909, complaining of frequency and occasional attacks of moderate hæmaturia during the preceding ten years. During the last six weeks he had attacks of severe pain localized to the area of the right kidney, and had lost twenty-five pounds in weight. The pain was not so intense if he drew up his right leg.

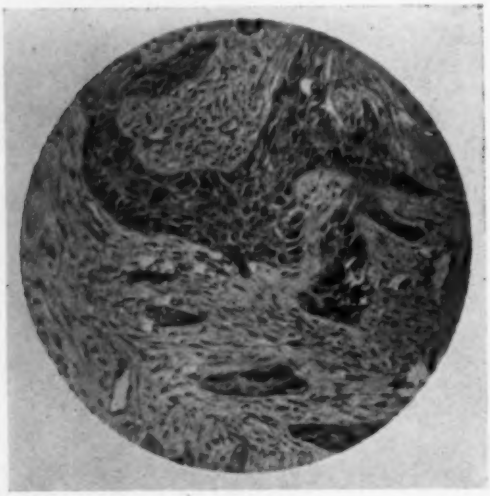

Fig. 9.—(Case A3809.) Extensive fibrosis causing distortion and constriction of an epithelioma of the renal pelvis.

Examination revealed a mass in the region of the right kidney. At operation a large infected kidney was removed through a Mayo lateral kidney incision. The kidney was adherent to the surrounding tissues and a subcapsular nephrectomy was necessary. Forceps were left on the pedicle, and five strips of iodoform gauze were packed in the wound. The forceps were removed on the fifth day and the patient left the hospital on the sixteenth day after an uneventful convalescence. Two months later the patient died. Necropsy revealed metastatic growths in the regional lymph-glands and in the liver.

Pathology.—The kidney was lobulated and soft. On cut section it was found to be almost completely atrophied and contained a huge staghorn calculus. Lining the pelvis and the calices, which were dilated and outlined by only a thin shell of cortical tissue, was a flat, irregular, somewhat villous growth. Histologic examination revealed a squamous-cell epithelioma with extensive hyalinization and epithelial pearl formation (Fig. 6). In most places the growth was confined to the lining membrane of the pelvis and calices, extending only slightly in several areas into the remaining parenchymal tissues.

Case IV.—(A138,795.) C. E. T., a man aged fifty-four years, came to the Clinic August 7, 1915, complaining of attacks of right renal colic and intermittent hæmaturia of twelve years' duration. Recently the pain over his right kidney had become more severe, and he had lost weight.

Examination revealed a smooth mass in the right abdomen. The urine contained a large amount of pus and blood; the phenolsulphonephthalein return was 44 per cent. in two hours and fifteen minutes. A röntgenogram revealed a large branched stone in the right renal area. Cystoscopic examination revealed a moderately inflamed bladder; the right ureteral orifice did not contract, and no secretion was seen during ten minutes' observation; the right ureter was catheterized and a small amount of cloudy urine obtained; the left ureter had an impassable obstruction at the orifice.

At operation a large solid, fibrosed kidney was removed. The patient recovered readily, leaving the hospital on the seventeenth day, but gradually became weaker and died two months after the operation.

Pathology.—On section, numerous fragments of a hard, black, irregular stone were found imbedded in firm masses of tough fibrous tissue (Figs. 7 and 8). There was no evidence of any normal kidney tissue remaining; the pelvis and calices were completely obliterated by an overgrowth of fibrous and malignant tissue. Histologic examination revealed a squamous-cell epithelioma. The normal mucosa surrounding the stones was replaced in many areas by a thickened, extensively hyalinized membrane; in other areas, due to infection and necrosis, no definite histologic structure could be made out.

Case V.—(A3809.) W. W., a man aged sixty-four years, came to the Clinic November 16, 1907, because of a mass in the abdomen, first noticed two months before. He had had several attacks of abdominal pain nineteen years before. For the last sixteen years he had had intermittent attacks of hæmaturia, during the last six months this hæmaturia had been almost constant, and was associated with severe pain in the left loin. He had lost 30 pounds in six months.

Examination revealed a pale, emaciated old man with a palpable tumor in the left side of his abdomen. The tumor was about 12 cm. in diameter and moved on respiration. Cystoscopic examination revealed frequent spurts of clear urine coming from the right ureteral orifice; the left orifice was slowly exuding thick, hemorrhagic, cloudy fluid.

A left nephrectomy was performed. The patient had an uneventful recovery from the operation, but never completely recovered his strength, and died several months later.

Pathology.—The kidney was increased in size and contained a number of large, irregular stones. The tissues adjacent to the renal pelvis and to the calices were soft, friable and white in color, and extended in irregular bands throughout the renal cortex. Histologic examination revealed a squamous-cell epithelioma originating in the areas adjacent to the pelvis; bands and masses of tumor cells also extended into the deeper tissues. There was a moderate hyalinization and epithelial pearl formation, together with an extensive fibrosis of the whole kidney. There were numerous large irregular cells, many of them containing mitotic figures (Fig. 9).

SUMMARY

Squamous-cell tumors of the renal pelvis probably result, in most cases, from chronic irritation, are highly malignant, rapidly involve the renal parenchyma and neighboring tissues, and readily metastasize. This type of growth is at times found in association with renal calculi, which are rough, irregular, and of tremendous size. Owing to the lack of symptoms suggesting a malignant condition, these tumors are rarely seen when the growth is small or localized to the renal pelvis. The operative mortality is high, and the majority of patients who survive die shortly after the operation from local recurrences, or metastatic growths.

Five cases of squamous-cell tumors of the renal pelvis have been observed at the Mayo Clinic between 1907 and 1922. Four of these cases were associated with renal stone; the calculi in three kidneys were extremely large and of the staghorn type. One patient died eight days after operation, three others died during the first four months. The fifth patient is alive without symptoms of recurrence six months after operation.

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SURGICAL TRAUMA OF THE RECURRENT LARYNGEAL NERVE WITH RESTORATION OF FUNCTION

By Adrian S. Taylor, M.D.

of Peking, China.

from the department of surgery, peking union medical college

In the Annals of Surgery, February, 1924, Frazier discusses the problem of paralysis of the vocal cords following surgical trauma to the recurrent laryngeal nerve and reports four cases in which improvement followed anastomosis of the distal stump of the divided nerve with the descendens hypoglossi. Several years ago Judd, New and Mann [1] reported experimental study of the regeneration of this nerve and the restoration of its function after surgical trauma. They concluded that:

"1. Section of the recurrent laryngeal nerve produces complete paralysis of the vocal cord of the corresponding side, which in all probability will be permanent.

"2. Ligation of the recurrent laryngeal nerve with linen, chromic catgut or plain catgut produces complete and probably permanent paralysis of the vocal cord of the corresponding side.

"3. Stretching the recurrent laryngeal nerves acutely in a manner similar but of longer duration and intensity than occurs in operation does not impair the function of the vocal cord.

"4. Stretching the recurrent laryngeal nerves for a long period, as over muscles, impairs the function of the vocal cords, but the impairment is probably due to the operative trauma and not to the stretching.

"5. Pinching the recurrent laryngeal nerves with a hæmostat in a manner similar to that which may occur in an operation produces temporary paralysis of the vocal cords. Restoration of function always occurs, the length of time necessary for restoration depending on the anatomic point at which the nerve was crushed. The time found necessary for complete regeneration of the nerve when injured in the areas usually traumatized by operation varies between thirty and sixty days.

"6. Exploration of the recurrent laryngeal nerve produces an effect on the vocal cords depending on the amount of trauma to which the nerves are subjected. Careful dissection will probably not produce any effect; the paralyses noted were probably owing to pinching and other traumatic procedures."

In the case which is here reported an operation was being done for unilateral ligation of the superior thyroid artery at the upper pole of the thyroid. During the dissection the recurrent laryngeal nerve was mistaken for the artery and was doubly tied with fine silk ligatures and partially divided between the ligature before the mistake was discovered. Paralysis was immediate, and

[1] Annals of Surgery, 1918, vol. lxvii, pp. 257–262.

was repeatedly verified by expert laryngoscopic examination. The patient was carefully observed in the follow-up clinic, later underwent a partial thyroidectomy and at the present time has entirely regained the function of the injured nerve.

Because of the accurate knowledge of the type and the extent of the trauma inflicted with subsequent complete recovery from the paralysis which immediately followed, this report is made.

The patient, a Chinese male student, aged twenty-one, was referred by Doctor LaForce, of Tsing Hua College, with the diagnosis of hyperthyroidism. On admission he showed the characteristic signs and symptoms of Graves' disease, with a basal metabolic rate of 66.5 per cent. above normal. His condition was so advanced that it was thought prudent to do a preliminary ligation under local anæsthesia.

August 5, 1922. After local infiltration of .5 per cent. novocain-epinephrin solution, a short transverse incision was made over the upper pole of the palpable gland on the right side. The preglandular muscles were split vertically and retracted, the upper pole of the gland being easily exposed. A pulsating cord was seen at the inner margin of the upper pole, and in spite of some doubt as to its identity, two fine silk ligatures were tied about it 0.5 cm. apart. These ligatures were then used to raise the cord from its bed, and partial section of it was made with a scalpel. Approximately one-half of it had been divided when cut ends of nerve fibres were recognized. The patient was immediately asked to speak, and was found to be characteristically hoarse. The silk ligatures were at once divided and removed. The remaining undivided nerve tissue served to hold the cut ends in good approximation and no attempt was made to suture them. The superior thyroid artery was then identified lateralward, tied and cut close to the upper pole of the gland. The pulsation erroneously observed in the nerve was later seen to be transmitted impulses from the artery.

The clinical picture improved after this ligation, but the patient left the hospital without improvement in his voice. Examination made August 8, 1922, by Dr. Harry Slack, Visiting Professor of Otolaryngology, showed complete paralysis of the vocal cord on the right side. The patient was seen again a month later and no improvement had occurred in his voice. Upon advice he left college, and rested a year at his home in Shansi Province, returning for further treatment in November, 1923. Examination on admission showed marked improvement in his general condition, the quality of the voice was normal, and laryngoscopic examination by Dr. A. W. Dunlap, Professor of Otolaryngology, in the Peking Union Medical College, showed both cords to be entirely normal in function. On December 1, 1923, a partial thyroidectomy was done under ether anæsthesia. The operation was easy, the gland was rather more fibrous than usual and presented grossly the typical picture seen in exophthalmic goitre. After operation, laryngoscopic examination was repeated by Doctor Dunlap on December 7th and the cords were again found to be entirely normal.

The case presents definite evidence of immediate and complete paralysis of one vocal cord after double ligation with fine silk of one recurrent laryngeal nerve with hemi-section between the ligatures, which were removed as soon as the mistake was discovered. Restoration of function was complete within sixteen months.

TRANSACTIONS

OF THE

PHILADELPHIA ACADEMY OF SURGERY

Stated Meeting Held April 7, 1924

The President, Dr. Edward S. Hodge, in the Chair

ECHINOCOCCUS CYST OF THE OMENTUM

Dr. K. Kornblum presented an Italian man, aged twenty-eight years, who was first seen by him October 28, 1923, complaining of a tumor in the right upper abdominal quadrant. He had been perfectly well until four months prior to admission, when he noticed some soreness in the right upper abdomen where he then felt for the first time a large mass that he could easily move about. He thinks the mass gradually increased in size from the time that he first noticed it. He had been in this country for the past twelve years. In Italy he was employed as a carpenter and in this country he has always worked in a factory. He had never been in intimate contact with dogs. He was muscular and well nourished, apparently in perfect health.

Examination was entirely negative with exception of the abdomen. Here a large tumor could readily be seen in the upper right quadrant, about the size of a cocoanut. This was not tender to palpation, presented a smooth surface and had a tense, cystic feel. It moved downward on respiration, appeared to be independent of the liver and no enlargement of this organ could be detected. The mass was freely movable in the upper abdomen and could be pushed slightly beyond the midline toward the left. In a downward direction it could be made to reach the level of the umbilicus. The mass appeared to have its centre of rotation about the gall-bladder. It could not be palpated with the hand in the right kidney region, neither could the right kidney be felt. A dull note was elicited on percussion over the tumor. No hydatid thrill was detected. No other masses were felt in the abdomen and the other abdominal viscera appeared normal. Peristalsis was normal and there was no abdominal distention. He was admitted to the service of Dr. George P. Muller, operation was performed on November 3, 1923, under gas-ether anæsthesia. A transverse incision in the upper right quadrant of the abdomen was made. The mass immediately presented itself on opening the peritoneal cavity and was seen to be a large cyst enmeshed in the great omentum and not attached to any of the neighboring viscera. The omentum was bound by adhesions to neighboring structures and could not therefore be removed from the abdomen. Consequently the cyst was walled off from the remainder of the peritoneal cavity by gauze packs and its removal proceeded with. In attempts to free it, the cyst wall was ruptured and immediately numerous daughter cysts escaped, thus revealing the true nature of the cyst. The entire growth was removed and after removal of the packs the abdomen was irrigated with a weak iodine solution. Further exploration of the abdomen revealed no other cysts. The abdomen was closed and the patient made an uneventful recovery. Pathological examination of the cyst showed it to have the usual characteristics found in echinococcus cysts. The patient has returned twice for follow-up examinations and states that he remains perfectly well. Physical examinations on both occasions were negative.

Echinococcus cyst of the omentum is but one of the varieties of this parasitic infestation of the peritoneum. Much of the literature concerning hydatid disease comes from Australia from which fact an inference may be drawn that the disease is probably encountered there as often as anywhere in the world. And yet the occurrence of peritoneal echinococcus cyst is a condition of comparative rarity in that country, as pointed out by Fairley who, states that, "Echinococcal infestation of the peritoneum is a relatively uncommon disease." In a series of 300 cases of hydatid disease encountered in 13 years only 25 were found to be of peritoneal origin. This author gives a rather lengthy dissertation on the occurrence of echinococcus cysts of the peritoneum showing that the disease occurs in two forms, either as a single cyst, such as the case reported this evening or as multiple cysts. Of the two varieties the occurrence of multiple cysts is about twice as common as the single variety. The single cysts are thought to be the result of an active migration of the embryo from the gastro-intestinal tract, while in the case of multiple cysts the most likely origin is from the rupture of a liver cyst either spontaneously or at time of operation. In Fairley's series of cases 88.2 per cent. gave a history of a previous initial operation for abdominal hydatid disease or of some previous acute abdominal crisis often traumatic in origin. The diagnosis becomes relatively simple in the case of multiple cysts because of this history of previous disease, but more difficulty is encountered with the single variety. In this respect it is interesting to note that in Fairley's eight cases of single cysts none were correctly diagnosed prior to operation. He calls attention to the fact that single cysts occur most frequently in the pelvis and in this situation in the male the most common error in diagnosis is to mistake the cyst for an enlarged prostate while in the female the cases are frequently diagnosed as ovarian cysts or myoma uteri.

As to the symptomatology, there is usually nothing more than the presence of single or multiple masses in the abdomen associated with various pressure symptoms depending upon the situation of the cysts. Certain complications are occasionally met with, the most common being a calcification of the cyst wall which results in an increased hardness of the mass and thus leads to the diagnosis of a solid tumor. Suppuration may occur in the cyst with its resulting toxemia which thus increases the difficulty of diagnosis. And finally a cyst may rupture. This quite commonly follows an injury to the abdomen. In addition to the symptoms of an acute abdominal catastrophe there are those resulting from the anaphylactic response on the part of the body to the fluid of the cyst. This is manifested by severe collapse, dyspnœa, cyanosis, vomiting and diarrhœa, rapid and barely perceptible pulse and later the occurrence of a symptom which is practically pathognomonic for the rupture of an echinococcus cyst is the development of urticaria. Thus the history of an acute abdominal catastrophe in a native from southern Europe associated with collapse and urticaria practically makes the diagnosis of the rupture of an echinococcus cyst.

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ANKLE FRACTURES

DR. E. L. ELIASON reported the following cases:

I. *Fracture of the Tibia and Astragalus with Dislocation of the Latter.*—The patient, a young man, had his foot caught between an ascending construction elevator and the side of an open shaft, with a resulting twist that threw him over the side to the ground, 30 feet below. Fluoroscopic examination revealed a fracture of the lower end of the tibia passing obliquely across the shaft and entering the joint, a fracture of the neck of the astragalus and an internal postero-lateral dislocation of the head of the astragalus with a 90 degree rotation of the same. Open reduction was required at which the tibialis anticus tendon was found between the fragments of the tibia. The head of the astragalus was entirely separated from its attachment. Reduction and plating of the tibia. The patient is now fourteen weeks later, walking with a cane.

II. *Bilateral Fracture of the Astragalus, Tibia and Fibula.*—A young woman, while riding in the side car of a motor cycle was subjected to a head on collision. The neck of the left astragalus was broken, dislocated laterally, accompanied by a fracture of the external malleolus. The neck of the right astragalus was broken, the head was dislocated laterally and both malleoli were broken. The patient was walking without a cane six months later, her only complaint being weak arches for which she wears supports.

Stated Meeting Held May 5, 1924

The President DR. EDWARD B. HODGE in the Chair

PLASTIC SURGERY OF THE FACE

DR. ROBERT H. IVY presented a man, seventy-one years of age, who for the preceding five years had been the subject of a slowly advancing ulcerative lesion of the skin of his nose. The skin of the entire nose was involved, presenting red thickened areas, large scales and crusts, which when removed exposed ulcerations. The ulcerative process had destroyed most of the left ala through its entire thickness, the skin of the columella, part of the cartilaginous septum, and the skin of the right ala. (Figs. 1 and 2.) Very little pain was experienced. Wassermann reaction was negative. General physical examination revealed no other serious defects.

FIG. 1.—Side view of nose lesion.

A plaster-of-Paris impression of the face was taken and a cast made of the same material. From this measurements were accurately made of the nose, which had been reconstructed in wax on the model, from which a tin-foil pattern was reproduced giving the exact shape and size of a forehead flap to be used in reconstruction of the nose. At the first operation, December 21, 1923, under ether, the flap of skin and subcutaneous tissue the size and shape of the tin-foil pattern was raised from the forehead and sutured back in place for

delayed transfer to the nose (Blair, V. P., Surg., Gynec. & Obst., 1921, vol. xxxiii, p. 261). On January 15, 1924, under ether, all of the diseased portions of the nose were excised. These included the whole of both alæ, the tip, the columella, the cartilaginous septum and all of the skin of the dorsum up to the

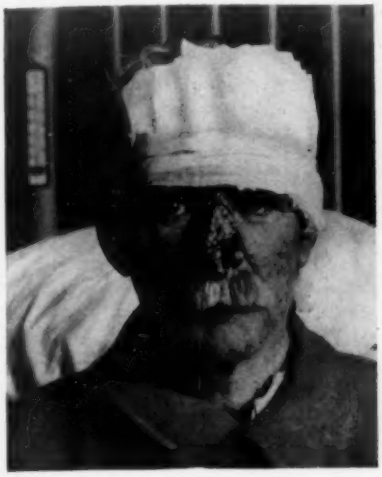

FIG. 2.—Front view of nose lesion.

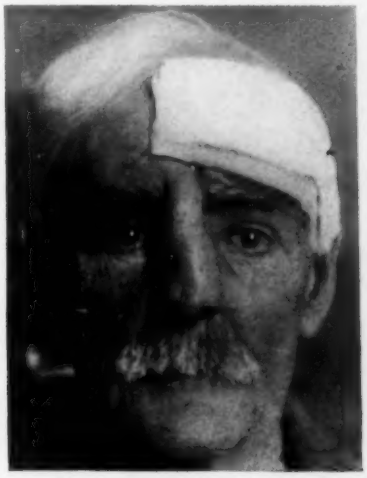

FIG. 3.—Defect of nose replaced by forehead flap.

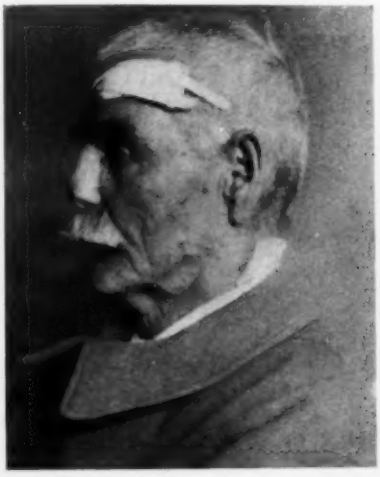

FIG. 4.—Side view after severing pedicle and returning it to forehead.

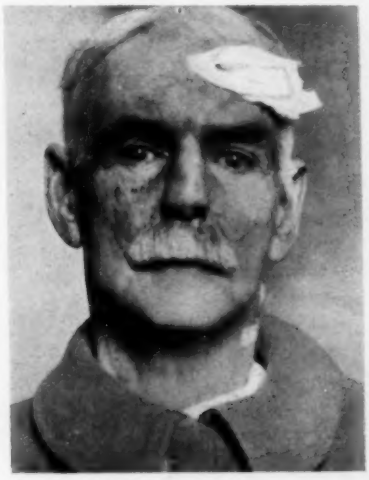

FIG. 5.—Front view after severing pedicle.

frontal bone. After control of hemorrhage, the forehead flap previously outlined was again raised, and sutured down into position so as to restore the missing parts (Fig. 3). The flap was so fashioned that its distal end could be turned in to form the lining of the nostrils and the columella, as well as supplying the external covering of the nose. This particular method of forming the flap made from an accurately measured pattern and furnishing in one piece, lining, columella and external covering, was devised by V. P. Blair, of St. Louis, by whose permission I am presenting it for the first time, as it has not yet been

published by him. Examination of the discarded tissue showed basal-cell epithelioma. On February 14, 1924, four weeks later, under ether, the pedicle was divided and its proximal end replaced in the forehead. The remaining raw surface on the forehead was allowed to granulate for a time and finally covered with a Thiersch graft under local anæsthesia. (Figs. 4, 5 and 6.)

FIG. 6.—Showing well-formed nostrils with airway.

Owing to the fact that the nasal bones and bony septum were not involved in this case it was unnecessary to insert any new bone or cartilage. Healing occurred promptly, giving the patient a natural-looking nose, with well-formed alæ and nostrils through which he can breath and blow. Time alone will determine whether or not the original lesion is cured, but it is hoped that the patient, who had been condemned to a miserable life of hopeless isolation, will be given at least a few more years of happiness.

Details in the steps of procedure in this Indian method of rhinoplasty as designed by Blair are:

(1) Making of a plaster-of-Paris cast of the patient's face.

(2) Building up of the defective structures to the desired form on the cast in wax or clay.

(3) Measuring the dimensions of the nose on the cast and plotting these out on paper (see diagram Fig. 7), making allowances for columella and lining of nostrils.

(4) Reproducing the paper plan in heavy tin-foil (Fig. 7).

(5) Applying tin-foil pattern to forehead, the pedicled flap is outlined, raised, and sutured back into original bed for delayed transfer (Fig. 8).

(6) Two weeks later, all external surface of nose is removed together with diseased or deformed deeper tissues, the forehead flap is raised and its distal end is turned in and sutured with catgut to form columella and lining of nostrils (Fig. 9). The flap is then rotated on its pedicle and sutured to edges of nasal defect, particular care being taken to fix posterior end of columella securely to top of upper lip.

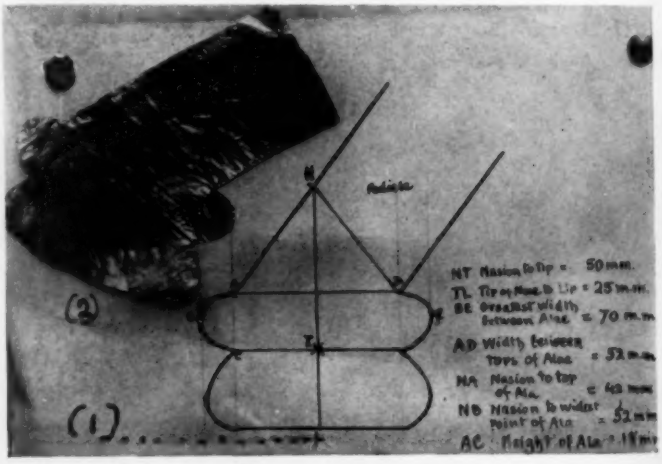

FIG. 7.—(1) Dimensions of flap for new nose plotted out on paper. (2) Paper plan reproduced in tin-foil.

(7) Three or four weeks later, pedicle is divided along line from top of one ala to nasion. Raw edge is sutured, and pedicle returned to forehead.

(8) Remaining defect in forehead can be immediately covered with full-thickness skin graft from abdomen, or later covered with Thiersch graft.

In most cases, even of total destruction of the nose, this soft tissue flap alone will restore the natural prominence of the nose without a bone or cartilage transplant. If more stability is desired, a piece of costal cartilage can be inserted later. Dr. Douglas Webster, of the Evans Institute, University of Pennsylvania, made the plaster casts.

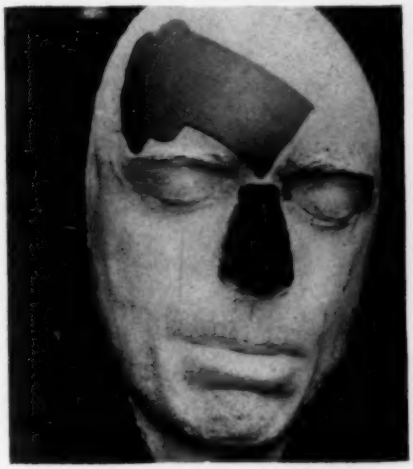

FIG. 8.—Plaster cast showing nose built out in wax and position of forehead flap.

DR. ROBERT H. IVY presented, also, a child eleven years of age, who had a large defect in the right side of the nose and cheek, exposing to view the interior of the nose and maxillary sinus. The defect communicated with the mouth through a small opening in the alveolar process on the right side. There was a loss of several teeth and surrounding bone in this region. The right ala was absent. From contraction of scar tissue the right corner of the mouth was drawn up at the expense of the upper lip. The remaining part of the nose was drawn toward the right. (Fig. 10.) This deformity is said to have resulted from noma following typhoid fever at the age of three years. On the right cheek are two parallel scars about an inch apart running downward and backward toward the neck, apparently due to a previous attempt at closure of the defect. The procedure for relief in this case was as follows: A plaster-of-Paris cast of the face was made and the defect built out to as nearly correct contour as possible in wax on the cast. From this a tin-foil pattern was made to give correct size and shape for a skin flap to cover the defect.

FIG. 9.—Under surface of flap, showing method of folding distal end to form columella and lining.

At the first operation, using the tin-foil pattern, a horizontal skin flap was outlined and raised from the forehead with its pedicle based at the right superficial temporal artery. This flap was sutured back into its original bed for delayed transfer to its new position. At the same operation a flap of skin was raised from the right infraorbital region, to be turned over like a hinge at the edge of the defect, to line the cavity with epithelium. This flap was also sutured back for delayed transfer.

Two weeks later, the nasal edges of the defect were freshened and the infraorbital flap raised, inverted, and sutured to the freshened nasal margin. The raw surface thus created on the cheek and the under surface of the hinge flap were covered by the horizontal flap from the forehead. (Fig. 11.)

Two weeks later, good union having occurred, the temporal pedicle was severed and returned to the forehead. The raw edge of the flap was sutured to the cheek. The opening into the nose was thus closed, but there remained

the drawn up right corner of the mouth. (Fig. 12.) This was corrected by dividing the scar tissue in the upper lip, bringing the corner of the mouth down, and filling the space thus created by interposing a thick tongue-shaped flap of skin and subcutaneous tissue from the lower lip. (Fig. 13.) Massage

FIG. 10.—Showing defect in side of nose.

FIG. 11.—Temporal-pedicled forehead flap brought down to close defect.

FIG. 12.—Temporal pedicle severed and returned to forehead. Right corner of mouth still drawn up.

FIG. 13.—Present condition, after adjustment of corner of mouth with ascending flap from lower lip.

and time are expected to do much to obliterate the scars of these various operations. Further correction of the nasal deformity may be attempted later.

COMPOUND FRACTURE-DISLOCATION

DR. DRURY HINTON (by invitation), presented a man, forty-five years old, who was admitted December 24, 1922 with a *compound fracture-dislocation at the wrist*. The radius protruded from the flexor surface, connected with the semilunar. Vessels and nerves retracted and posterior. Four hours after admission, operation was performed, the semilunar being removed and the

wound closed without drainage after replacing the tendons and vessels. Put in splint; slight fixation, active motion in 3 days, drainage for 2 days. Left the hospital on the ninth day and was referred to surgical dispensary and at the end of three weeks was off splint and at the end of four weeks, was back at work. His work is that of a painter and he still has some slight difficulty. An interesting feature of this case was that the wound was filled with paint and turpentine.

CASE II.—*Compound Fracture-dislocation of the Elbow.*—Patient fell 20 feet and had a Colles' fracture of the right wrist and a compound fracture-dislocation of the left elbow. The humerus was pushed out one inch from the inner aspect of the arm. Fracture of the epicondyle and also fracture of the other condyle. Brought in 3½ hours after accident. Operation and placed in Jones position, small rubber tissue drain, removed at the end of 48 hours, active motion for 3 days, then motion every other day for three weeks, then all dressing removed and he returned to work in three months. Since then has had no trouble. Full flexion, supination and pronation.

TRAUMATIC PNEUMOTHORAX

DR. T. J. RYAN (by invitation) reported the case of a boy seven years of age who was admitted to the Misericordia Hospital on December 7, 1923, on Doctor Muller's service with the history that an auto truck had passed over the lower part of his right chest. Upon admission shortly afterwards he was found suffering from severe shock with a sub-normal temperature, a pulse rate of 120 and a respiratory rate of 48. He was coughing and vomiting blood. He was not totally unconscious. Examination revealed distention and rigidity of the right thorax, drum-like resonance, and evidence of injury to the ribs. There was marked distention and rigidity of the abdomen with considerable tenderness over the hepatic area.

Stimulants and an intravenous infusion of saline solution were administered within an hour after admission. Two days later, although the condition of the patient was poor and his heart sounds very feeble, an X-ray picture was taken of his right chest which disclosed fractures of the fourth, fifth, seventh, eighth and ninth ribs with a pneumothorax of the entire chest and a complete atelectasis. The right chest was aspirated and air escaped under considerable pressure. The patient was immediately benefited and an X-ray picture taken on December 17, 1923 revealed expansion of the right lung to about 60 per cent. of its normal size. The patient was discharged twenty days after admission having no symptoms except very slight pain over the chest wall. His respiratory rate was 24, his pulse 100 and his temperature 98.

This condition is not a frequent complication of civil injuries, having been the first one that occurred in this service at the above hospital in five years and but few have been described in the literature since 1917. It seems to be the consensus of opinion that these cases will recover without aspiration, but it would seem that the treatment which was instituted was instrumental in hastening recovery.

RESUSCITATION OF AN ARRESTED HEART BY DIRECT CARDIAC MASSAGE

DRS. WALTER ESTELL LEE, and T. MCKEAN DOWNS read a communication with the above title for which see page 555.

PHILADELPHIA ACADEMY OF SURGERY

SURGICAL TREATMENT OF BRONCHIECTATIC CAVITIES

Drs. Thomas A. Shallow and Louis H. Clerf read a paper with the above title.

LATE RESULTS OF SPLENECTOMY FOR TRAUMATIC RUPTURE OF THE SPLEEN

Drs. Damon B. Pfeiffer and Calvin M. Smyth, Jr., read a paper with the above title, for which see page 562.

BILIARY TRACT SURGERY

Drs. James H. Baldwin and William R. Gilmour read a paper on Biliary Tract Surgery, based upon a study of 130 consecutive surgical cases.

TRANSACTIONS
OF THE
NEW YORK SURGICAL SOCIETY

Stated Meeting Held April 9, 1924

The President, Dr. Eugene H. Pool, in the Chair

BILATERAL STRANGULATED INGUINAL HERNIA IN THREE MONTHS' OLD BABY

Dr. Henry W. Cave presented a child, a premature seven months' baby, at the present time aged three months, who was admitted to the Second Surgical Division, Roosevelt Hospital, March 7, 1924.

Forty-four hours before a left indirect inguinal hernia came down into sac and became irreducible. The bowels moved four hours prior to admission. The patient was vomiting about every hour. Fecal odor to vomitus.

The baby was poorly developed, and had a hard irreducible mass in left scrotal sac. Hoth baths; ice-bags and upright elevation of buttocks failed to reduce hernia.

Forty-five hours after hernia became incarcerated the patient was operated upon. Drop ether anæsthesia. Inguinal canal exposed. Release of constricting ring. Several loops of small intestine congested and bluish in color reduced. Closure of neck with fine catgut. Sac not removed. Wound closed. Satisfactory recovery.

Eight days post-operative: A bulging mass appeared in the region of the right external ring. Was reduced with some difficulty. Ether had to be given. Four days later this bulging mass again came down into sac and was irreducible. Under ether anæsthesia, this right-sided irreducible indirect inguinal hernia was operated upon. Numerous loops of small intestine of bluish color reduced. Suture of neck. Closure of wound. Slight amount of infection, lower angle. Satisfactory recovery.

STRANGULATED INGUINAL HERNIÆ WITH BEGINNING GANGRENE OF TESTICLE IN THREE AND ONE-HALF MONTHS' OLD BABY

Doctor Cave presented a child who, when a baby three and one-half months old, was admitted to the Second Surgical Division of Bellevue Hospital, March 2, 1923, at 10 A.M., for relief of strangulated right indirect inguinal hernia of fifty-five hours' duration.

Operation was performed within an hour of patient's admission. Drop ether anæsthesia. Incision over inguinal canal. A loop of small intestine filled with semi-solid fecal matter was found caught in the external ring and pressing firmly against the cord. The loop of gut was a very dark brown, not quite black. The entire cord, the testicle and epididymis were black. After a slit was made in the ring and the gut drawn out, the circulation was restored in a few minutes. The scybalous mass pushed upward in lumen of gut. Hernia reduced. Cord and testicle still black. Even in spite of the threatened gangrene of the testicle and cord, it was thought best not to remove them. Closure of hernia opening, repair of canal in usual way. Child made an uneventful recovery. Discharged cured from hospital nine days after operation.

BRAIN TUMOR

DR. CHARLES A. ELSBERG presented a woman, thirty-four years of age, from whom he had removed an endothelioma from the left motor area, under local anæsthesia, in January, of last year. One year before she began to have attacks of twitching in the right hand and forearm which continued off and on and which was soon followed by attacks of twitching of the right side of the face and right upper and lower extremities. She was never unconscious during the attacks and they occurred every few days. She was treated in the Out-patient Department, where it was found that she had a four-plus Wassermann, and received thorough antispecific treatment. She never had any headache and never vomited. She was admitted into the hospital in a condition of status hemi-epilepticus. Every ten to fifteen minutes she would have a convulsive attack which began in the right upper extremity and then involved successively the right side of the face and the right lower extremity. She was conscious during all of the attacks. She was under observation for two days during which time there was progressive weakness of the limbs on the right side. Upon physical examination, her fundi were found to be normal, tendon reflexes on the right side greater than on the left with a Babinski on the right and with marked weakness of the right upper and lower extremities. The Wassermann in the blood and cerebrospinal fluid was negative. At the operation, a well encapsulated endothelioma, 5 x 4 centimetres in size, was removed from the left arm area. As there was a great deal of bleeding from the cavity in which the tumor lay, a small piece of muscle was removed from the thigh and inserted in the cavity and the bleeding thus controlled. The patient recovered very satisfactorily from the operation. She rapidly regained power in the right side of the body and was free from the Jacksonian attacks. She returned to the hospital three months later and was then practically well. Two months after this she began to have recurrences of her attacks and by November—ten months after the operation—she was having attacks every few weeks with again a progressive loss of power in the right upper and lower extremities. November 13, 1923, the bone flap made at the previous operation was again turned down, and the dura opened; the piece of muscle that had been implanted at the operation ten months before was found to be lying loose in the cavity and to have undergone fibrotic change. The piece of muscle which was 3 x 2 centimetres was easily removed and the wound then closed. She recovered satisfactorily from the operation, rapidly recovered power in the affected limbs and has been free from the convulsive attacks. When the piece of muscle was incised it was found that there was a collection of pus, sterile on culture, in the centre of it.

In this patient, the implanted muscle acted as a foreign body and had to be secondarily removed. It had caused a recurrence of tumor symptoms. The Wassermann was found to be positive again, and she was put upon renewed antispecific treatment. It seems very probable that the lues had something to do with changes due to the fact that the implanted muscle was not well borne by the tissues, as muscle is usually borne well when it is implanted and never causes any trouble as in this patient.

DOCTOR ELSBERG presented also a woman from whom he had removed a large endothelioma from the left fronto-parietal region. Sixteen months before the operation she complained of some double vision and some dimness of vision. This continued off and on for six months and then she began to have headaches, increasing in severity, and buzzing in the ears. For seven weeks she had had some disturbance in speech, often misnaming objects and people. Upon examination, the reflexes on the right side were slightly exag-

gerated over those on the left. There was a marked papillœdema on both sides and a facial weakness on the right of the central type. The diagnosis of a tumor in the left frontal region was made, and in October, 1923, a large osteoplastic flap was turned down on the left side; the dura was very tense and the attempt to puncture the ventricle was unsuccessful. The patient stood the operation very poorly and further procedures were delayed for four days. The bone flap was then turned down again and the dura widely opened, exposing a large endothelioma, which was excised. There was considerable bleeding from the bed in which the tumor lay, and a large piece of muscle was removed from the thigh and inserted in the bed of the tumor, thus controlling the bleeding. The patient was considerably shocked by the operation, requiring active stimulation and blood transfusion, but she recovered very satisfactorily thereafter.

Doctor Elsberg presented a third patient from whom a tumor had been removed from the same region. This woman first complained of diplopia four months before followed by headache and vomiting. The symptoms persisted and the headaches became gradually more severe, and she complained of a great deal of dizziness and of attacks of coldness in the left side of the face with buzzing in her right ear. There were no convulsions or other symptoms. Upon physical examination, there was a slight increase of the reflexes on the right side, a bilateral papillœdema with hemorrhages and a slight right facial weakness of the central type. There were no speech disturbances. The operation was done in May, 1923, and a large endothelioma removed from the left fronto-parietal region. The patient recovered very satisfactorily from the operation and has remained well.

Both these patients presented very similar symptoms and it was interesting that both of them complained first of double vision, so that the question of encephalitis was considered. Both of them complained of auditory disturbances in the contralateral ear, which is unusual in tumors of this location, and in both of them the paucity of clear physical signs is of interest.

Doctor Elsberg presented a fourth patient from whom he had removed a very large tumor from the right frontal region, under local anæsthesia. The man was seen in an advanced state of tumor symptoms referable to the right hemisphere, with marked papillœdema, diminution of vision and mental disturbances. The tumor was so large that it had to be removed in several pieces. The patient stood the operation very well and recovered satisfactorily as far as all of his symptoms were concerned excepting the visual disturbances. After the operation the papillœdema, which had been of high grade with a large amount of exudate, rapidly subsided, but it was followed by so much postneuritic atrophy that the little vision that the patient had before the operation was almost entirely lost.

This case demonstrates how unfortunate it is to delay operative interference too long, for there is nothing more pathetic than to have a patient lose his vision after a very satisfactory tumor removal.

In answer to a question, Doctor Elsberg said that in his intracranial work for some years he had been making very large bone flaps which extended from above the frontal sinus in front to the level of the mastoid behind and up to the median line. This avoids secondary rongeuring away of bone if the tumor is found near the median line and allows of much freer manipulations. In some instances tumors are well exposed by these large flaps which otherwise might be missed altogether. When the bone flap is returned into place without removal of additional bone, the cranial cavity is closed entirely. If

the tumor is expected in the occipital region, then the bone flap is made further backwards up to the level of the transverse sinus.

COMPOUND COMMINUTED FRACTURE OF SKULL WITH LACERATION OF BRAIN IN A CHILD FOLLOWING COASTING

Dr. Hugh Auchincloss presented a boy, eleven years old, who on January 15, 1922, two years, three months ago, was brought to the Emergency Ward of the Presbyterian Hospital (No. 52622) by two men who said that while coasting in Central Park he ran into a park bench and cut his head open. Though seemingly unconscious, he responded in monosyllables a few times to questions. He was cyanosed, was somewhat dyspnœic, had cold, dry

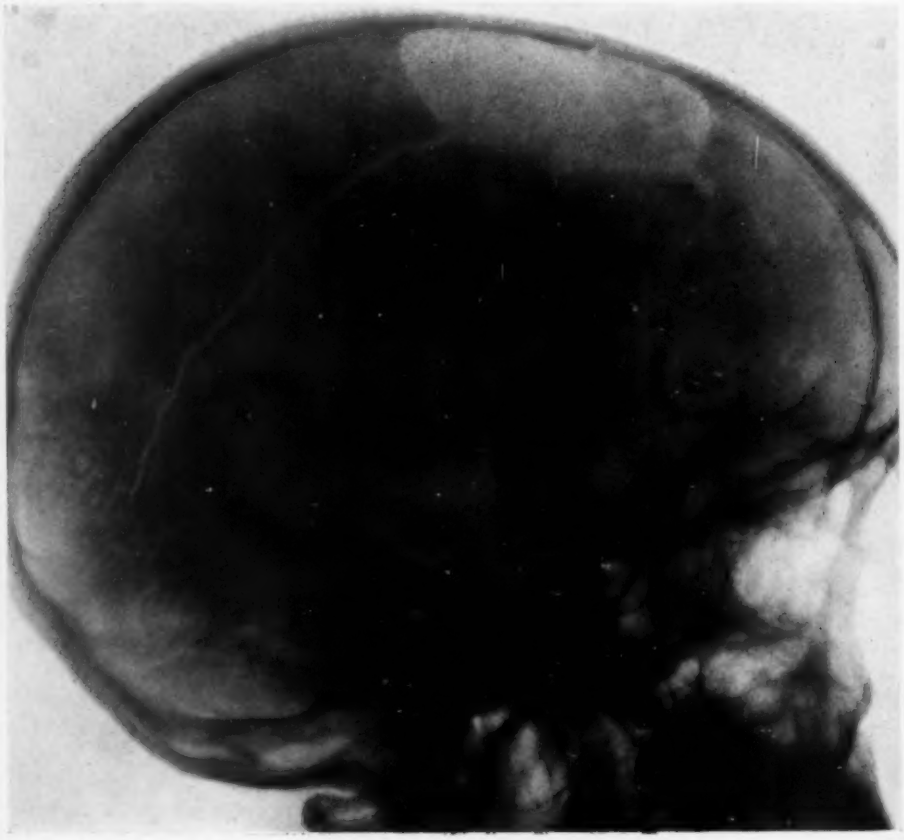

Fig. 1.—Skiagraph showing defect in skull after recovery.

hands and feet and looked shocked. In striking contrast to a fractured skull picture with compression signs, his pulse varied between 120–150, was of good quality, and his blood pressure 125/70.

An irregularly curved scalp wound just above the hair line in the frontal region lay open, exposing blood clot, some dirt, and hair matted together with a friable substance that proved to be bits of brain. No other evidence of injury was found. Dr. H. A. Murray, who was then house surgeon, hurried him at once to the operating room, where he was first seen by the reporter. Great care was taken in the wound preparation. Shaving, cutting

away fragmented flap edges, removing dirt, and gentle irrigation with slightly warmed saline, then Dakin's solution took about half an hour, during which time the pulse ranged between 100 and 150 and the blood pressure 100/40 to 125/75. A little ether had to be given to keep him quiet. The scalp was avulsed from before backward with a pedicle behind. Six fragments of the vault lay depressed beneath the edges of the surrounding normal skull. In most of these fragments the amount of inner table fractured was greater than the outer. They were made up of the frontal and left parietal bones. (Fig. 2.) Close to the longitudinal sinus was a laceration of the dura mater about 2 x 3 cm. in diameter whence came brain tissue. Small fragments of it oozed out. It was thought to be just in front of the upper part of the precentral convolution. No bleeding vessel of any size was found. The bone fragments were removed. Great effort was made to thoroughly remove all foreign matter, clean and rearrange the tissues, closing the dura and then the flap with as little trauma as possible. Two little rubber drains at either end of the wound were inserted. The last part of the operation was completed by Dr. W. G. Penfield. Subsequent X-rays showed a linear fracture radiating toward base on left side.

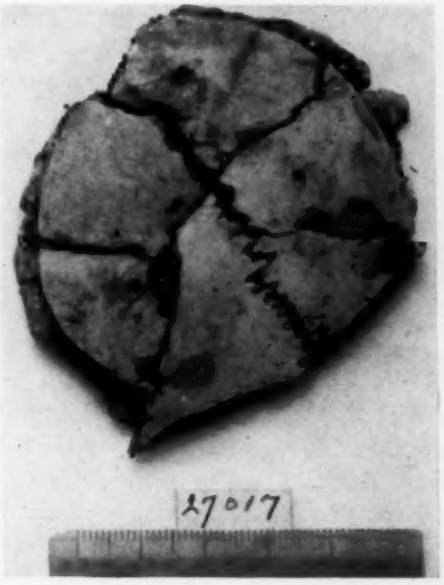

FIG. 2.—Fragments removed.

The blood pressure remained about the same during the rest of the afternoon and at midnight, though his pulse was 130, he spoke a few words and said he "felt fine."

Except for some relative weakness in the grip of his right hand and an intercurrent attack of tonsillitis his post-operative course was free of noteworthy happening. He went home 23 days after his injury with a pulsating defect in his skull, measuring 6.5 cm. in greatest diameter. (Fig. 1.) Four days later Doctor Penfield noted: "The wound is entirely healed. The surface where the brain was exposed pulsates and is slightly depressed. He has no pain on getting up in the morning or on stooping over, Babinski's are both normal. Abdominal reflexes normal. Strength in right hand normal. No cortical sensory loss can be made out. He has a slight internal strabismus of the left eye which may have been present before. On looking to the left there is a moderate nystagmus with quick phase to the left. On looking to the right there is a fine nystagmus with quick phase to the right. The question of filling in the cranial gap must be considered and determined by such disturbances as headache and focal symptoms."

Four months later. Quite well. Five months later. Broke his humerus. Eight months later. Went with Tribune Fresh-air Party to the country. Nine months later. Quite well. Defect in skull is flat. Twenty-one months later. Pain at site of depression for one week. Very marked pulsation present and it can be seen at a distance. Doctor Penfield advises closure of defect. Thirty-two months later. Occasionally a little dizzy. No headaches. Thirty-five months later. Apparently some difficulty with memory. Passed up a

grade in school only on trial. On stooping, gets dizzy, also if struck on head. Vomited supper one month ago. Family are not particularly anxious to have any operation at present.

Reasons for presentation of case:

1. The magnitude of the injury received while coasting down what most people would consider a rather harmless looking short, not particularly steep, Central Park hill.

2. Severe brain laceration and loss of substance with relatively insignificant signs and symptoms as compared to apparently much less severe fractures associated with bleeding within the closed cranium. A somewhat dramatic evidence of the value of "decompression" coincident with injury.

3. A three-year follow-up result at eleven to fourteen years of age, showing scarcely any complicating feature as yet. It is hoped that later follow-up results may be obtained and reported.

Dr. Charles A. Elsberg said that he thought unless the defect were very large and the patient had a disturbed symptomatology, it was better to allow the flap defect to remain. He considered that in this boy it might remain with perfect safety and with the outlook that in a few years it would decrease in size. Unless there was some special reason for acting otherwise, he would leave that flap alone.

Dr. Seward Erdman was interested to know the indication for the removal of so large an amount of bone. He inquired if there was any reason for believing, if it was not contaminated, it was not safe to leave it in. He believed that in such cases as this an effort should be made to leave in as much of the comminuted bone as possible as it fills in the defect and acts as a bone graft.

Doctor Auchincloss, in closing the discussion, said that at the operation it was a debated point what to do with the pieces of bone. They were taken out and preserved in saline until a decision was reached regarding using them. But there was hair and ground-up dirt mixed with them and Doctor Penfield rejected the use of that bone from the standpoint of the undesirability of having a possible infected foreign body in the wound, especially in a case where the dura had been opened and there was so extensive brain laceration.

SUPPURATIVE ARTHRITIS OF KNEE-JOINT TREATED BY INCISION AND MOTION

Dr. Frederick T. van Beuren, Jr., presented a woman, forty-four years of age, who was delivered at the Sloane Hospital for Women February 1, 1923. Five days postpartum she had a rise of temperature to 104 degrees F., and complained of tenderness in the right lower quadrant of the abdomen. Eight days postpartum she complained of tenderness in both iliac fossæ and the uterus was found to be enlarged and irregular. A diagnosis of septic uterus and probable pelvic thrombo-phlebitis was made. Nineteen days postpartum swelling and tenderness of the right knee-joint was discovered and pus was aspirated which showed streptococcus hemolyticus on culture. He saw the patient for the first time on the following day, and deferred operation for twenty-four hours in order to force the fluid intake and digitalize her because she was in very bad general condition with a temperature varying from 103 to 104, and a white blood count of 18,000 with 83 per cent. polymorphonuclears. February 22, 1923, incisions were made, one on the outer,

the other on the inner side of the right patella, draining the knee-joint; immediately upon coming out from the nitrous-oxid anæsthesia, motion of the right knee-joint was instituted, partly active, partly passive, before the dressing was applied. A large quantity of thick pus was forced out of the joint by this movement and redressing with assisted active motion was performed every three hours while the patient was awake during the next two weeks. During the next four weeks, although the blood culture showed no growth on four or five separate occasions, she developed a very large abscess in both gluteal regions one month later and an abscess in the right pectoral region about ten days after the development of the gluteal abscesses. The cultures from the pus in each case grew streptococcus hemolyticus. These complications interfered seriously with the care of the knee-joint. For thirteen weeks the patient ran a more or less high temperature, continuously, and her general condition was very bad indeed. During the greater part of this time active motion at the knee-joint was impossible on account of the patient's inability to perform it, but passive motions were kept up by the interne, Doctor Damon, who had immediate charge of the conduct of the case. Eight weeks after the incisions in the knee-joint had been made, the inner wound had closed off from the joint and was healed at the end of fourteen weeks after operation. The outer wound ceased to discharge at about the same time, but was not healed until about sixteen weeks after the operation. The healing of the wounds in the gluteal and pectoral regions was also very slow, the pectoral wound healing about five months after it was made. There still remains, thirteen months after the operation in the gluteal region, a small sinus over the sacrum.

She got out of bed for the first time eight months after the operation on her knee and began to walk about one month after that, having considerable difficulty on account of contraction of the posterior leg muscles. She is now, thirteen months after the operation, able to walk up and down stairs with moderate ease. She has full and painless active extension of the right knee-joint to an almost complete degree. This case is shown to emphasize the fact that it is possible to secure a good result in suppurative arthritis of the knee-joint by incision and motion of the joint, even in a most unfavorable case, provided sufficient pains are taken by the interne in charge of the case. It is further emphasized that, in this case, passive motion or a combination of assisted active motion with passive motion, took the place of real active motion for a number of weeks and secured a satisfactory result.

Dr. Royal Whitman considered that complete extension at the knee-joint was, from the functional standpoint, more important than freedom in flexion. He thought that in such a successful case an attempt should be made to restore extension and thus to assure stability in weight bearing.

Dr. Allen O. Whipple considered that this case presented the best proof of the wisdom of operating to restore function in suppurative arthritis occurring in such desperately sick people. These patients with suppurative joints are so often desperately ill in so many other ways that the accomplishment of such a result, as seen in this patient, was a very remarkable one. Most of these cases go on to a bony ankylosis, if they get well at all.

TRAUMATIC RUPTURE OF THE LIVER

Dr. Benjamin T. Tilton presented a man, twenty-two years of age, who was admitted November 22, to St. Mark's Hospital with a history of having fallen one-half hour before, four stories, while at work on the construction

of a new building. On admission his condition was that of marked shock; blood pressure 100 over 52, temperature normal, pulse 100, respiration 22, red cell count 3,600,000, hæmoglobin 70 per cent. He complained of severe pain in the abdomen and left shoulder, and had vomited before admission.

On physical examination, the patient was pale. The abdomen showed no external evidences of injury, was slightly distended, and there was moderate spasm of the muscles, particularly on the left side. There was marked tenderness in the left upper quadrant. There was shifting dulness in the flanks. Percussion, palpation and auscultation of the chest gave no evidence of thoracic injury. Catheterization of the bladder showed no blood in the urine. The patient had abrasions of the left forehead, fracture of the nasal bones, fracture of the lower end of the left radius, fracture of the left scaphoid and a comminuted fracture through the greater trochanter of the right femur.

Laparotomy was performed four hours after the accident. The abdomen was opened through the left rectus and a very large amount of fluid and clotted blood was found. The spleen was uninjured, but on the under surface of the left lobe of the liver there was a deep tear about four inches in length which extended on to the posterior surface of the organ. The laceration was bleeding freely. As the patient's condition was very critical and the torn surface was very inaccessible for suture the wound in the liver was merely packed with a large amount of plain gauze which was brought out through the upper end of the laparotomy incision. A hypodermoclysis was given on the table. Post-operative condition very bad. With the aid of repeated hypodermoclysis, fluids by rectum and stimulation the patient gradually improved and went on to a slow but complete recovery. One week later the gauze packing was removed under gas and oxygen anæsthesia, liberating a large amount of bloody, broken down liver tissue. There was a discharge of thick purulent material for several days following the removal of the packing. The temperature which reached 104–6° twelve hours after operation fluctuated in the neighborhood of 102 to 103 until the packing was removed, after which it gradually reached normal.

He left the hospital about eight weeks after admission. He had remained in the ward longer on account of baking and massage of his fractured femur and wrist. An interesting question in this case is the nature of the injury that produced the rupture of the liver. It seems possible in the absence of external evidences of injury to the abdominal wall or thorax that the injury to the liver was not caused by compression of the organ, but rather by a pulling away of the liver from its parietal attachments by the sudden force of the fall. This indirect method of injury is more likely to affect the heavier right lobe; rupture of the left lobe is comparatively rare. The chief point of impact seems to have been over the greater trochanter on the right side which was markedly comminuted. As regards operative procedure, he believed that gauze packing is the method of choice where time is an important element and the hemorrhage is still active. This can of course be combined with suture in suitable cases.

RUPTURE OF THE SPLEEN IN A CHILD FOLLOWING RELATIVELY SLIGHT TRAUMA

Dr. Fordyce B. St. John presented a child, nine years of age, who was brought to the hospital in a taxicab three months ago by her mother to determine whether or not an injury existed.

The history as presented by the mother was as follows: Two and one-half hours before admission, while in school, one of her little friends gave her a push while she was standing near a school desk and she bumped up against

the corner of the desk, striking her left side and sliding to the floor. Immediately she felt a sharp pain in her left side under the ribs, did not fall down, however, but sat down in a chair for five minutes and then as school was over walked home partly supported by two girl friends, climbed two flights of stairs, and then because she felt badly lay down on a sofa.

About an hour and a half later she felt nauseated and vomited twice, chiefly yellow fluid. This did not alarm her mother as the child in the past several years had not infrequently vomited with so-called indigestion attacks. She did not complain of pain while lying quietly either before or after vomiting but said that walking and moving had hurt her side. A short time later, however, perhaps fifteen minutes, the mother noticed that the child was paler than usual, especially about the lips. Upon arriving at the hospital by taxicab, the child walked into the accident ward with her mother and sat down in one of the receiving chairs to wait for the examining physician.

A half hour later, four hours after injury, when seen by the visiting surgeon, she presented the following picture: A pale child about eight or nine years old lying on the examining table with knees drawn up, apparently not in acute pain, but very quiet. Respirations were quiet and not increased in rate, her pulse rate was 98, fair in quality, the red cell count being 4,500,000 and the hæmoglobin 85 per cent. She seemed like a matter of fact youngster and stated that while lying still she had no pain, but that she felt more comfortable with her legs drawn up. She was not nauseated. The examination of the chest was essentially negative, except for slight diminution in respiratory excursion. The abdominal wall moved with respiration but was also limited in its excursion. A very faint area of ecchymosis was noted over the lower left chest in the splenic area pressure on which caused no pain. It was difficult for the child to relax her general abdominal wall with the thighs extended. With the thighs flexed she presented slight spasm in the upper left quadrant with tenderness and less spasm and tenderness in the lower left quadrant. There was no costo-vertebral tenderness, but very definite dulness in the left flank, not shifting, and tympany in the right. A rectal examination was not made.

It was felt that with the history and the evidence of intraperitoneal injury with hemorrhage and from the location of the blow and the ecchymosis found, a ruptured spleen seemed the most probable pathology with probably some renal injury.

She was operated upon immediately and the following conditions found. Upon opening the peritoneal cavity through a left rectus incision there escaped a large amount of fluid blood and the examining hand placed in the upper left quadrant could readily appreciate a badly lacerated spleen, which, however, upon being brought into view, was not apparently otherwise pathological. The visceral surface presented a longitudinal rent which almost completely divided the spleen into two equal halves. Controlling the pedicle of the spleen with the fingers, clamps were applied including the vessels, and the spleen removed. Large blood clots were noted in the left lumbar gutter and in the left subphrenic region behind the stomach. At the time the spleen was first seen there was very active hemorrhage present. After removal of blood clots in the left lumbar region retroperitoneal hemorrhage was noted in the region of the left kidney, which upon palpation showed no evidence of gross laceration, however. The wound was closed with continuous plain gut for the peritoneum, during which about 350 c.c. of hot saline were introduced into the peritoneal cavity. The anterior sheath was repaired with chromic gut and the skin and subcutaneous tissue with silk. Note: It was estimated that the

amount of blood in the peritoneum including clots was about 400 c.c. A saline infusion was given on the operating table.

The pathological report of Doctor Stout describes the spleen 8 cm. x 5½ x 3 cm. "Its visceral surface presents a longitudinal rent which almost completely divides the specimen into two equal halves. The surfaces along the line of rupture are very jagged, the substance of the spleen bulges forth and there is much blood clot. The rupture goes through to the diaphragmatic surface but there it is not so accentuated. There are, however, three distinct lines of rupture, the main line running somewhat longitudinally, while the other two are perpendicular to this and take their origin from it. Microscopic examination: Section of the spleen taken along the margin of one of the cracks shows adherent to it a mass of coagulum with thick plaques of fibrin and flaklets separating the mass of red blood cells. There has been some degeneration of splenic tissue along the margins of the rupture. There is considerable leucocytic infiltration along the surface of the splenic tissue and into the coagulum. Many of the phagocytic cells of the spleen are loaded with brown granular blood pigment. There is almost no hemorrhage into the splenic tissue itself."

On the day following operation the child was transfused with 400 c.c. of maternal blood and following this the post-operative course was uneventful until the ninth day, when the dressing was noted to be soaked with bright blood and upon its removal a disrupture of the wound found which was repaired immediately with general anæsthesia followed by an uneventful convalescence, the patient being discharged from the hospital on the thirty-sixth day following injury with the following blood count: red blood cells, 4,200,000; hæmoglobin, 70 per cent.; white blood cells, 400; polymorphonuclears, 37 per cent.; lymphocytes, 52 per cent.; l. monos. and trans. 10 per cent.; eosinophiles, 1 per cent.

RUPTURE OF LIVER IN A CHILD FOLLOWING COASTING

Dr. Hugh Auchincloss presented a twelve-year-old school girl, who while coasting in Central Park, February 26, 1924, collided with a tree and struck her right side, over probably, from her description and a skin mark, the lower ribs about the anterior axillary line. After being pulled along on her sled for a short distance she was able to stand up but, when she did so, complained of pain in her abdomen much worse on breathing deeply. From Fifth Avenue and Seventy-second Street to First Avenue and Seventy-fifth Street is about ten blocks, or half a mile. She walked this and then up one flight of stairs. Because she looked pale and still complained of abdominal pain her sister brought her to the Presbyterian Hospital (No. 59284) in a taxicab. The physicians who then examined her were called upon to reconcile a somewhat conflicting assortment of facts.

She was thirsty and asked for water frequently. When she breathed, she had much pain referred to the right acromial region, but no evidences of injury were discovered there. She was wholly conscious, talkative and smiled during the remissions of pain and after her chest was strapped. No signs of a rib nor lung lesion could be made out and the heart was not displaced. These negative findings were substantiated by fluoroscopy. Over the tenth rib in the right anterior axillary line was a little reddened skin evidently where she had been struck. The right side of the abdomen, the right flank, and both recti were rigid. In the right costovertebral angle there was no tenderness nor spasm. One of the physicians found on rectal examination that on the right side high up it seemed more tender. There was no psoas spasm.

The catheterized urine showed strongly positive guaiac, 8–10 red blood

cells to a field and a very definite ++ glucose reaction. Blood sugar as subsequently reported was normal, 1.03 gms. L. Temperature, 99.4; pulse, 100; respiration, 28; leucocytes, 27,000; polymorphonuclears, 80 per cent.; blood-pressure, 108/70; red blood cells, 4,400,000; hæmoglobin, 80 per cent. No bile present in blood serum.

At midnight, four hours later, leucocytes 22,000, polymorphonuclears 82 per cent. One A.M. vomited considerable stomach contents, felt better and went to sleep. It was then thought she might have a rupture of the kidney and retroperitoneal extravasation of blood and urine.

At nine the same morning the reporter first saw her and was told that though it had been decided to wait a few hours for more definite indications as to operation and where to operate, her condition was not as satisfactory as it had been hoped it might be. Temperature, 100.4; pulse, 110; respiration, 20; red blood cells, 3,500,000; hæmoglobin, 70 per cent. Chest was strapped; nothing definitely abnormal made out there. Didn't want to move because of pain in lower chest and upper abdomen. Abdomen was somewhat distended and slightly tender everywhere, especially on right side. Spasm corresponded. The costovertebral angle was not tender and she moved her legs freely. The rectal examination was very conclusive, a boggy mass in the cul de sac that was exquisitely tender. Chest and abdominal X-ray plates were negative.

Because of the signs of peritoneal irritation that had become evident, the abdomen was opened in the midline under novocain. About 400 c.c. of blood was sucked out from the peritoneal cavity. The rest of the operation was done under ethylene and oxygen. By extending the incision upward blood was found coming from the right upper abdomen and a tear could be felt in the right lobe of the liver. Spleen, kidneys, pancreas, gut, stomach and retroperitoneal spaces all appeared normal. A slightly oblique incision was then made below right costal margin. A ragged tear was found running horizontally across the greater part of the right lobe, with a mass of brownish-yellow fibrin about it. It readily admitted the finger tips. Two Mikulicz type of vaseline and iodoform gauze tampons were placed between the torn liver and the ribs, with small soft rubber tubes between. The middle wound was closed with chromic to the sheath and through-and-through silkworm gut tied on buttons. The inner part of the transverse wound was similarly closed.

There was a free discharge of bile for nearly a week after operation. On the ninth day under gas anæsthesia the packing was removed practically without bleeding. She went home thirty-one days after the operation, nine days ago. The bloody fluid in her peritoneal cavity contained bile pigment and showed no bacteriological growth. Her clinical recovery, except for a superficial spot where the drains had been, and some weakness, has been satisfactory considering the time elapsed.

Reasons for presentation of Case: 1. An example of serious visceral injury incidental to the apparently harmless sport of coasting down one of the little Central Park hills.

2. A child can walk a half mile with an extensive rupture of the liver.

3. Red blood cells appeared in five urine specimens during the first two days yet no gross nor other clinical evidence of kidney rupture was found. Possibly an intracapsular injury.

4. A definite glycosuria with normal blood sugar was found. A similar glycosuria has been found in other serious traumatic cases. These cases have interested Dr. L. Bauman, who is seeking further data and more cases before making an analysis as to its significance or pathogenesis. Occurring as it did in this case with a normal blood sugar it suggests a so-called renal type of glycosuria.

5. If, when the peritoneum had been opened under novocain, some of the bloody fluid had been examined at once for bile pigment, a procedure that would not have taken more than about five minutes, it might have contributed somewhat toward the diagnosis of liver or bile passage rupture, though probably not have materially altered the procedure.

ABDOMINAL CONTUSIONS ASSOCIATED WITH VISCERAL INJURY

DR. GEORGE E. BREWER read a paper with the above title.

DR. CHARLES N. DOWD said that he had recently had tabulated the cases of abdominal contusions at Roosevelt Hospital for the last few years. He was surprised to find how few of these cases had been operated on, and as this hospital is located in a neighborhood where there are many accidents, every day various people are brought in with injuries from automobiles, falling from heights, etc. The method of handling them has been, when the case needed operation, not to delay at all. There have been cases, however, where there was doubt whether operation was desirable and these have caused much anxiety. As they have recovered without operation, they cannot be classed as rupture of the liver, or spleen, for there is no proof, so they are listed as abdominal contusions. There was usually an autopsy performed on those that died so it was possible to put on the history, "Rupture of the Liver," or "Rupture of the Spleen." Consequently the hospital records do not give one an accurate idea of the real number of these cases of rupture of a solid viscus that have come in because so many have gotten well under the diagnosis of "Abdominal Contusions."

There are eleven of these tabulated cases of rupture of the liver and of the spleen gathered from the hospital records. Of that number there were seven deaths, which does not give much encouragement for operation. One case of splenectomy died immediately, two died after palliative operation, one not operated upon died. There were three other deaths, one after operation; so operation was done in four and the operation was of no avail in any of them. In the cases cured there was one hepatorrhaphy, repair of a small tear in the right lobe, but there was not more hemorrhage than is often seen in a gall-bladder operation where a small area of the liver is exposed. In another there was a little crack in the liver two inches long, and in another there was rupture of the spleen where only exploratory was done, and in another there was rupture of the kidney. These got well. Speaking from the records of the first surgical division of this hospital for the last few years (not very severe cases, but taking them as they come in) there had been little in the way of encouragement for operation. In the next few years the preponderance of cases may be those that need operation and will get well with it. But although watched with great care and operation done on all that needed operation, it would not seem that operation had been very encouraging in these cases.

DR. JOHN F. CONNORS said that in his experience at Harlem Hospital he was changing the methods of treatment in these cases of intra-abdominal injuries and that less operations are being performed. In many cases it is the

opening of the abdomen which decreases the intra-abdominal pressure and causes renewed hemorrhage when if the abdomen was allowed to remain closed and the intra-abdominal pressure not interfered with, bleeding would not recur. The attitude in these cases is much the same as that adopted in cases of fractured skulls. Operation was formerly done on all these cases and the mortality was high. Since stopping routine operation in these skull cases the mortality has been greatly reduced. Many cases of intra-abdominal injuries are operated upon too early and if they were observed for a while many less operations would be done and the end results would be better.

In the last year there have been quite a number of cases where there was blood in the urine, none of which came to operation, the urine cleared up, and the patients recovered. There have been cases in which there might have been a ruptured spleen, but of course there being no operation, diagnosis was made solely from the patient's condition and the blood picture. In none of these cases in which no operation was done was there a fatality.

Doctor Connors said that he had looked up the statistics at the hospital and found that from September 1, 1923 to April 1, 1924, fifteen cases were admitted to the hospital with a diagnosis of intra-abdominal injury. Of these, four cases were the results of falls; one patient fell four stories, there was ecchymosis on the left side, blood in the urine, patient was in shock, no operation, recovery. Of the four cases there was one operation, in which ruptured gut was found, patient died. In these four cases there was one operation, one death; three non-operative cases, three recoveries. Two cases were crushed, neither of which were operated upon, both recovered. Seven were struck by automobiles; two operative cases, one death; five non-operative cases, one death. There was one case in which the patient was coasting; blood in the urine, no operation, recovery. One patient was struck by a plank from a circular saw, operation, ruptured gut was found, recovery. Of the fifteen cases there were five operative cases with three deaths. There were ten non-operative cases with one death, which would seem to indicate that a policy of watchful waiting was giving the best results. Of course, in cases of ruptured intestine there can be but one method of treatment and that is immediate operation.

Dr. John Douglas called attention to the trivial amount of trauma that sometimes results in great injury. He remembered four cases of solid viscus injury, after not very severe accidents, one a motorman who was struck by the backward swing of the brake on his car which caused a rupture of the kidney; another case was that of a small boy who was struck a glancing blow by an ice wagon with a result of rupture of the spleen, another a ruptured kidney following a fall from a bicycle and a ruptured liver following a fall from a wagon, the three last cases being children. As to the symptoms in these cases, it is not always possible to make a diagnosis. While rigidity and shifting dulness are the two best signs, it is difficult to differentiate the signs of hemorrhage from those of shock. Doctor Douglas had seen a woman lately who had been run over in the iliac region and was contused and black

and blue locally, and it was difficult to tell on examination which was voluntary rigidity from tenderness due to local injury and which involuntary rigidity from intraperitoneal hemorrhage. She had no pulse at the wrist, hæmoglobin was 70 per cent., and there were 4,000,000 red blood cells, and the extreme pallor, air hunger, and weak and rapid pulse seemed at first to indicate an internal hemorrhage.

The speaker had met with one case of retroperitoneal rupture of the duodenum. In this case there was infiltration from leakage down behind the ascending colon to the cæcum. If he had been operated on immediately it is doubtful if the lesion would have been found. As to the hemorrhage following the opening of the peritoneum, he had one case of ruptured liver that died almost immediately after the peritoneum was opened, although the preoperative condition did not appear a desperate one. As far as rupture of the kidney is concerned, in which the kidney was sutured, he thought this procedure was rarely successful. He remembered one case in St. Luke's Hospital in which there was continued bleeding and the hæmaturia continued until the kidney had to be removed several days later. In addition to having transfusion ready to use at the time of operation, it is a help to leave in the abdomen every bit of blood possible, the same as in operation from a ruptured ectopic pregnancy and fill the peritoneal cavity up with saline before closure. He believed a considerable amount of blood is thus saved and absorbed back into the circulation.

Dr. Benjamin T. Tilton said that he had seen a transverse fracture of the body of the pancreas produced by direct traumatism. The patient had been caught between a heavy trunk and the side of a baggage car. There was a large amount of blood in the lesser sac and the case terminated fatally from shock and hemorrhage. He thought it should be recognized that hemorrhage behind the peritoneum could give symptoms like those of an intra-peritoneal injury, such as marked tenderness, muscular rigidity and later peritoneal irritation. Such a condition should be thought of before deciding on operation for supposed visceral injury.

Dr. Hugh Auchincloss said he did not consider an immediate operation harmful if a small incision was made and a local anæsthetic used. He thought it was not safe if an intraperitoneal injury were suspected to let it go. The operation can later be made more extensive if necessary.

Doctor Brewer, in closing the discussion, said he wanted to emphasize what Doctor Tilton said. He had seen large retroperitoneal extravasation simulate peritoneal irritation. An interesting case which he had not mentioned in his paper was that of a child brought in with a severe abdominal injury and indefinite symptoms. There were symptoms of considerable shock and an exploration was done and rupture of the pancreas was found. A large packing of gauze was put in and a cigarette drain surrounded by rubber tissue to bring about absorption of the pancreatic fluid as otherwise there would have been extensive fat necrosis.

Regarding conservative as opposed to the radical measures in these cases, there is ground for both views. There are many slight injuries that recover spontaneously, but one cannot know they are slight; as a rule they are severe.

The speaker could not agree with Doctor Connors as to letting all the kidney cases go without operation. In one of his cases, the kidney was torn in three pieces and it was doubtful if there would have been recovery without operation. Cases with enormous extravasation of urine would not recover. If a patient is pulseless, the color of white wax, has air hunger, and on opening the abdomen half a gallon of free blood escapes, that case will not recover without operation. If one in ten can be saved by timely operation in these severe injuries, this is doing pretty well. That type of case cannot be saved by conservatism.

Stated Meeting Held April 23, 1924

The President, Dr. Eugene H. Pool, in the Chair

THE ELECTRO-MAGNET-RADIATOR-VIBRATOR OF MÜLLER

Dr. William C. Lusk presented three patients who had been suffering from painful cicatrizing scars and a painful contusion, and who had been greatly benefited by treatment with the "electro-magnet-radiator-vibrator of Müller." He said that the quite remarkable properties of this device are but little known. The principle applied, which gave to the magnet its therapeutic value, was that the electrical energy should be furnished by the alternating current. The latter threw the magnetic field radiating from the instrument into a state of rapid oscillatory movement, which undoubtedly penetrated tissues placed within its influence. He used an alternating current which was generated by a rotary-transformer, the speed of revolution of whose armature increased with an increase in the strength of the current passed through the coil of the magnet, so that the number of cycles of alternation of the electric current per second varied from 63 to 73 in the range of strengths of currents used between seven and twenty-five ampères. For the latter two strengths of current, oscillatory motion was set up in the magnetic field at the rates of 7600 and 8800 oscillations, respectively, per minute. It had been thought that this variation in the cycles of alternation for different strengths of current passed through the coil of the magnet, might afford some explanation of the varying therapeutic effects exercised by the magnetic influence with the differing strengths of the electric current used. With the use of an alternating electric current generated by a rotary-transformer, a fifteen-ampère strength of current for the administration of radiation, had seemed to be the highest one advisable to employ. In the therapeutic administration of this radiating magnetic influence, the central spot of the magnet, near which the power of the magnetic attraction and the force of the oscillatory movement were greatest, should be placed directly over the site to be treated, which latter it was not necessary for the magnet to touch. The central spot of the magnet should be applied at intervals of about

two or three inches, generally for two minutes at each site. There were vibrators which, on being fixed to the end of the magnet, took up the oscillatory movement of the magnetic field. Radiation was usually applied to the tissues preceding the use of the vibrator. The vibrator had special uses and it was thought that it should best be applied only at intervals of a week or two or longer, in order to allow to take place a favorable reaction of the tissues, which it had seemed could then result following each use of it. A too frequent use of the vibrator had seemed often to intensify the symptoms for the relief of which it was being used. It should be applied with a thick cushion of flannel intervening between it and the tissues. Mr. Müller had cautioned against using it over the central nervous system. There was thought, as well, to be a reaction-time following each application, or several frequently-given applications, of radiation from the magnet, in which greater progress toward recovery of the tissues would take place if treatments were interrupted, than if they were continued to be given frequently. The speaker believed that this device afforded a new therapeusis for otherwise intractable painful cicatrizing conditions. The use of the magnet was illustrated by the history of the first case presented, which was as follows:

The patient was a physician, who on March 29, 1922, was given an injection of 1 c.c. of 80 per cent. alcohol, aimed through the mouth, at the right inferior dental nerve beneath the ramus of the jaw, and on the third day thereafter, no relief to the pain having resulted, a second similar injection was given into the same location and three days later the pain stopped. However, in about ten days more, the injected tissues had so contracted that the patient was unable to open his jaws wider than to attain a spread of about half an inch between his incisor teeth, and there was a quite severe boring pain on motion of the jaw, which continued up to the time of beginning treatments with the magnet on May 7, 1922. On this date he could separate his incisor teeth without pain only about ⅛ inch, further opening of his mouth causing pain, the maximum spread between the incisor teeth being to an extent that would just admit the distal interphalangeal joint of his index finger. The ingestion of food was attended with so much pain that he would stop eating in the middle of his meals. The painful area on spreading the jaws was located just behind the right ramus, a little above the angle of the jaw.

Between May 7 and 17, the patient received ten treatments with radiation from the magnet, and at the end of this time he considered that he could open his jaws to within about ¼ inch of their normal spread, and there was no pain at all on strongly stretching the jaws apart to the limit of the restraint.

This result came about as follows: At the first treatment, immediately following two minutes of radiation over the seat of the pain, using 17 ampères, the patient said that the pain was about 50 per cent. relieved, after one minute more of radiation there was greater relief, and then after waiting for half an hour the patient was able to open his lower jaw to the limit of the obstruction practically without pain. The following morning, before treatment, the pain on spreading the jaws was as bad as ever, but the jaws could be opened distinctly wider than before. Radiation, using 17 ampères, was now administered over the seat of pain as well as over the right temporomaxillary joint for two minutes apiece. On the third day, before treatment, the jaw could be opened nearly to the limit allowed by the restraint without

any pain, but at the limit the pain was as much as ever. The movement of the jaw had undoubtedly improved since the previous day. On the fourth day the patient reported less pain on eating. On this date the current was reduced to 12 ampères, which afterward became to be regarded as the correct strength of current for the treatment of a painful cicatrizing scar with radiation from the magnet, and soon the time of application of the radiation was established at three minutes over the temporo-maxillary joint and at four minutes over the angle of the jaw. Immediately following this treatment the pain caused by moving the jaw was controlled. On the fourth and the fifth days there seemed to be no increase in the spread between the incisor teeth. On the sixth day, on which no treatment was given, the patient was able to open his jaws to the limit with only slight pain, and on the seventh day, before his treatment, with no pain at all. On the latter date he was able to just get the proximal interphalangeal joint of his index finger through the spread between his incisor teeth. From now on, motion rapidly increased. On the eighth day he regarded that he could open his mouth 1/16 of an inch wider than on the preceding day and about ¼ inch wider than he could before the magnet was used, and he thought that the effort to stretch the scar was not quite so painful as it had been. On the ninth day the patient reported that when he stretched his jaws widely he had only a little pain and that he was eating with perfect comfort. He thought the spread had increased a little since the day before. On the tenth day he had practically no pain on "ordinary" stretching of his jaws. On the eleventh day, May 17, he had no pain at all with strong stretching of his jaws. The spread between the incisor teeth now lacked only about ¼ inch of the normal amount and he regarded the pain at the seat of the alcohol injections as cured and the jaw limbered.

The patient was next seen on May 24, when the spread between the incisor teeth had increased and was pretty nearly normal and there was still no pain associated with movements of the jaw. On this date he had one more treatment with radiation, using 12 ampères for three or four minutes, applied a little below the angle of the jaw, given for an unpleasant sensation which existed at this situation. The patient was next seen on June 15, when the spread between the teeth was practically normal and he could still force his jaw widely open without pain.

Thus this crippling cicatrization with its attendant pain was rapidly overcome, and it had not recurred.

FRACTURE OF THE SURGICAL NECK OF THE HUMERUS

Dr. Alfred Stillman presented a man, aged twenty, who on October 18, 1923 was thrown from the running board of an automobile, hitting on his right arm and shoulder, fracturing the surgical neck of the humerus and displacing the shaft markedly toward the axilla. The next day he was seen in the Roosevelt Hospital Emergency Department, was X-rayed and put up in an aeroplane splint. The following day he was admitted to the hospital, put to bed and the fracture treated by suspension of the arm in abduction with traction by 10 pounds weight. After three days of traction an X-ray showed better position of the fragments but no reduction. On the fifth day ether was administered and a very fair reduction accomplished by manipulation. A further effort made three days later without ether added a little more to this reduction. Union was firm in three weeks. The arm was taken out of the apparatus on the twenty-sixth day and the patient discharged. Function has been complete from the day of his discharge and a few days ago he played baseball.

This patient was shown to demonstrate what a good reduction can some-

times be made in a badly displaced fracture, and the early return of function in these cases treated in the abduction position as compared with those treated with the arm at the side. The latter take several months to regain function.

Doctor Stillman presented also a girl, aged thirteen, who fell on a doorstep March 1 and fractured the surgical neck of the left humerus. She was put up in a Velpeau bandage in the Roosevelt Hospital Emergency Department. Two days later she was admitted to the hospital, put to bed, her arm suspended in abduction with traction. The position of the fracture was found to be unchanged and an effort was made to get her parents to give permission for a general anæsthetic to be given so manipulation could be tried. This permission was not obtained until the 13th and the attempted reduction was not successful. She was taken out of the apparatus March 31 and discharged April 6. Function was nearly complete. The effort at reduction was too late. She was shown for the result despite the decreased angle which the shaft makes with the head.

SUBGLENOID DISLOCATION OF THE HEAD OF THE HUMERUS WITH FRACTURE OF THE GREATER TUBEROSITY

Dr. Alfred Stillman presented a woman, aged fifty-two, who fell against a trunk March 26, dislocating her shoulder and tearing off the greater tuberosity of the humerus. Her X-ray shows the fragment well separated. The dislocation was reduced and this procedure also reduced the fracture. She was discharged with her arm in a sling. It is now five weeks and function is nowhere near as good as in the other two treated in abduction.

ANKLE FRACTURE

Dr. John C. A. Gerster presented a stout man of sixty-two years, who sustained his injury on the night of February 17, 1924. The next day he was admitted to the service of Doctor Stetten at the Lenox Hill Hospital, with a fracture of the lower end of the fibula and of the tibia, the line of fracture running through the posterior part of the articular surface. There was marked backward displacement of the foot and leg with extreme swelling and ecchymosis. Two attempts at maintaining reduction in plaster having failed, a third attempt at reduction by suspension and moderate traction succeeded. A broad strip of adhesive was applied to sole and heel and kept in contact with the skin by a muslin bandage. To the free end of this adhesive, beyond the toes, a rope with eight pounds traction was sufficient to lift the foot clear of the bed. A Sinclair skate was then attached to the bandage covered foot and ankle by adhesive strips and covered by another bandage with six pounds traction applied to this. Reduction was immediately obtained and maintained. The Sinclair skate was removed within a few days but suspension was kept up for six weeks. After the first ten days' active flexion and extension of the ankle was begun. Total duration of stay in hospital was eight weeks.

The patient has about 30 per cent. of motion in ankle-joint at the present time and has resumed his former occupation as storekeeper. The difficulty in maintaining reduction was due to the fracture of the posterior part of articular surface of tibia which permitted the foot to slip backwards. The suspension of the foot made it possible for the weight of the leg to cause the unfractured anterior articular surface of tibia to move backward and assume its proper relationship with the articular surface of astragalus.

Slight eversion of foot was easily controlled by raising inner border of sole and heel ¼ inch.

LONGITUDINAL FRACTURE OF PATELLA

PLASTIC CLOSURE OF PERSISTENT THROUGH-AND-THROUGH SINUS OF LOWER THIGH

Dr. John C. A. Gerster presented a girl, eighteen years of age, who at the age of five suffered from an acute osteomyelitis of the lower end of right femur which was operated upon in another hospital. She was under treatment for thirteen months. Ankylosis of right knee resulted. Was then free from symptoms until one year ago when abscess in the old scar developed, which was drained and then closed.

She was admitted to Mt. Sinai Hospital, September 24, 1924 (Service of Dr. A. A. Berg) with a history of pain over lower end of right thigh, with fever and sweats for three weeks. September 26 abscess was opened and drained by Dr. J. Stenbuck. The abscess extended up behind femur for 4 inches. Bone not definitely diseased. Scars over both internal and external aspect of thigh over lower end of femur excised and through-and-through drainage established. Fever subsided promptly, but sinus refused to close. Injection of Beck's paste on one side caused escape of paste through sinus opening on opposite side.

Operation, December 22, 1923. Excision of old scars on inner and outer sides of lower thigh down to level of femur, exposing normal soft parts of leg just above knee except for ring of scar tissue comprising sinus as it passed behind the bone just above condyles. This ring of scar tissue was large enough to permit index fingers—introduced from each side—to touch behind bone. Just behind this ring of scar tissue and intimately adherent to it could be felt the femoral artery. As the removal of this scar would have been extremely difficult and dangerous, it was decided to fill the retro-femoral part of the sinus with a pedicle flap of muscle. Such a flap was accordingly obtained from the vastus externus with base opposite sinus opening. Its free end was drawn through sinus without tension and was sutured to soft parts of inner wound. Both internal and external thigh wounds were partly closed with interrupted sutures and drained. The patient had a long but uneventful convalescence, was discharged from the hospital February 1, 1924. She has shown no signs of infection since then.

Her old osteomyelitis resulting in ankylosis of right knee with shortening over 1½ inches produced a compensatory scoliosis.

Dr. H. H. M. Lyle emphasized the value of muscle grafts for plugging sinusus, bone cavities, etc. In his hands this method has given him far better results than fat grafts. Muscle grafts had succeeded in the head of the tibia, the condyles of the femur and in the humerus where fat grafts had been tried and failed.

LONGITUDINAL FRACTURE OF PATELLA

Dr. John C. A. Gerster presented a woman of sixty-three who on April 5, 1923, was in the act of boarding a street car when someone stepped upon her skirt and she fell forcibly upon her right patella. A few hours later when first seen there was an effusion into the knee-joint, but no limitation of active or passive motion. Localized pain and tenderness over patella. X-ray showed longitudinal fissure fracture running through outer third of patella, with slight separation of fragments. The knee was kept at rest in a compression bandage for ten days, after which she walked with a cane and made complete recovery in ten weeks.

MESENTERIC CYST CAUSING INTESTINAL OBSTRUCTION

DR. THOMAS ALLISON SMITH presented a girl from the Children's Surgical Service of Bellevue Hospital. Admitted January 21, 1919, age seven years. Six days before admission to the hospital she was taken sick with persistent vomiting, no food or liquid being retained. This condition continued up to the time of her admission. There was no pain. On the day following onset of symptoms her bowels moved thoroughly, but did not move again in spite of frequent purgatives. Examination showed a well-developed, but poorly nourished girl. Her abdomen was slightly distended, but there was no rigidity and only slight tenderness which was about one and one-half inches to the right and slightly below the umbilicus. Over the lumbar region posteriorly the muscles were rigid on the right side, and the child was very tender to fist percussion. Rectal examination revealed a mass in the right lower quadrant which seemed to be movable. Her temperature was 100, pulse 128. White blood cells 12,000, with 75 per cent. polymorphonuclears. Urine contained both albumin and acetone.

She was operated upon eighteen hours after admission, the operation revealing that there was a cyst of the mesentery producing an intestinal obstruction by twisting the bowel due to a slight rotation of this cyst. Because of the tightness of the obstruction due to the twist, it was thought best to excise this portion of the intestine, which was done, uniting the bowel by lateral anastomosis.

For the next two weeks this child's condition appeared to be very critical, with rapid pulse, abdominal distention, and fecal vomiting. She developed pressure sores over her occiput and back. Finally, on the fifteenth day, she developed a fecal fistula and from that time on, her condition improved. She was discharged at the end of seven weeks, and has had no abdominal complaints in the five years that have elapsed since her operation.

SUBCUTANEOUS LACERATION OF THE PANCREAS

DR. THOMAS ALLISON SMITH presented a boy from the Children's Surgical Service, Bellevue Hospital, age seven years. On the date of admission, March 29, 1918, the boy fell from a ladder a distance of about five or six feet, striking his abdomen and head. He was dazed for a few seconds, but was not unconscious, and walked into his house. About two hours later, he vomited clear fluid, and vomited again about an hour later, but complained of no pain except soreness under the left costal margin, where there was an abrasion of the skin and some ecchymosis. He also had signs of a contusion over his forehead.

Examination was negative except that his abdomen was rigid throughout and he had considerable tenderness on pressure, most marked midway between the umbilicus and the tip of the ensiform. His temperature was 99.6°, his pulse 96, white blood cells 18,000, 90 per cent. polymorphonuclears. Urine was negative except for a trace of albumin.

He was placed under close observation. During the night he vomited several times, and had some cough. During the next day, abdominal rigidity and tenderness increased, and the vomiting continued. For this reason, it was thought best to explore the abdomen, which was done about thirty hours after the injury. As soon as the abdomen was opened, there was found a small amount of blood-stained fluid. There were several small areas of fat necrosis in the gastrosplenic and gastrocolic omenta, also a tear about one inch in length in the gastrocolic omentum. This was enlarged, and the lesser peritoneal sac examined, which contained some bloody fluid and showed a

transverse tear in the tail of the pancreas about one inch in length and not more than one-eighth of an inch in depth. A cigarette drain was sutured to this tear and brought out through the gastrocolic omentum. No other abdominal injury was observed. For the next two weeks the wound drained very freely, the secretion digesting the skin about the wound. Within a day or two after the operation, his coughing and vomiting developed into a full-fledged whooping cough, which complicated the case and delayed healing. He was taken home by his parents thirty days after admission, with the wound still draining, but it was closed seven weeks from the date of injury.

Dr. William B. Coley said that he had had one case of rupture of the pancreas, an airman who fell from a great height during the war. He was operated on and developed a fistula. This finally healed up and he made an excellent recovery.

Dr. Hermann Fischer referred to a case of injury of the pancreas which he observed some ten years ago. A little girl had been run over by an automobile and was brought into the Lenox Hill Hospital severely shocked, with signs of intra-abdominal injury. The clinical signs pointed to an injury of the stomach, spleen, or pancreas. Laparotomy revealed a multitude of fat-necrotic areas in the large omentum. Stomach and spleen intact. On exposing the pancreas quite extensive fat necrosis in its vicinity was noted. The head and body of the gland was intact but its tail was crushed. A tampon was carefully adjusted around the injured portion; the bloody effusion which was present in the abdomen was removed by saline irrigation. The patient made an uneventful recovery.

Doctor Smith's and the speaker's cases are interesting because of the fact that in both the tail of the pancreas was the only portion involved. In crushing injuries it is usually the body which is caught between the lumbar vertebræ and the injuring force. Injuring of the body and head are more common and dangerous than injuries to the tail because the ducts of pancreas may be torn in body injuries. In Doctor Smith's case the lack of shock immediately after the injury should be noted as unusual.

OSTEOCHONDROMA OF VERTEBRÆ

Dr. Charles A. Elsberg presented a patient from whom he had removed a large osteochondroma of the vertebræ which had caused marked spinal compression symptoms. There was a history of four months of pain in the lumbar spine and increasing loss of power in the lower extremities. Upon examination there was a large, hard palpable tumor over the lower back and marked disturbances in the power, reflexes and sensation in the lower extremities up to the level of the eleventh thoracic segment. The X-ray showed a large calcified mass in this region which was diagnosed as a benign growth. The operation, performed in February, 1924, consisted of an extensive laminectomy and excision of a large chondroma of the vertebræ that compressed the cord. The tumor was well limited, smooth and glossy in appearance and surrounded by a large amount of new bone. The tumor was found to have crowded the dural sac markedly to the right and was removed in pieces with a large amount of new-formed bone around it. The growth was gradually followed to the right side of the bodies of the vertebræ and removal of this portion of the growth was very difficult on account of its close connection with the pleura. Portions of the left eleventh and twelfth ribs and the transverse

process of the twelfth thoracic vertebra that were involved in the growth had to be resected, and although great care was taken in freeing the tumor from the pleura, a large rent was made in the pleura. The rent in the pleura was closed by a continuous suture and the wound then closed. The patient recovered very satisfactorily from the operation and has been improving steadily since that time. The pathological report was osteochondroma.

Dr. William B. Coley asked Doctor Elsberg what his prognosis would be in this case. He was interested to know because he had seen similar cases pronounced chondroma by the pathologist which had later turned out to be malignant chondrosarcoma.

In answer to this question Doctor Elsberg replied that he considered the prognosis to be very good. The tumor was a benign one and was entirely removed. He thought the chances for recurrence were small. Although the patient still had a number of spinal symptoms, it was too soon after operation for them to have disappeared and they could be disregarded in making the prognosis. He had had two other cases of osteochondroma of the vertebra, although in neither was the growth as large as in this case, and both had been well for five years.

FRACTURES ABOUT THE UPPER END OF THE HUMERUS

Dr. Harold Santee read a paper with the above title, for which see Annals of Surgery, July, 1924, vol. lxxx, p. 103.

Dr. H. H. M. Lyle said that in looking up the history of his suspension frame (erroneously called the Balkan) he had found reference to this method as far back as 1812. The choice of the methods to be used depends on the amount of flexion, abduction and external rotation of the upper fragment. In the simple cases it is quite possible under ether to bring the lower fragment in line with the upper, to engage the ends and bring the arm down into mild adduction and maintain this position by weights or traction. Good functional results can be obtained without confining the patient to bed. If the relation of the parts cannot be maintained by these simple means, then the Whitman abduction shoulder spica or some form of platform splint embodying these principles should be used. These methods give excellent functional results and do not confine the patient to bed. There is another group of cases in which it will be necessary to use the suspension traction method as described in Doctor Santee's paper. This method has the practical disadvantage of confining the patient to bed for a period of three to four weeks. It is the method of choice in compound fractures and in gunshot wounds of the shoulder.

In the cases associated with dislocation of the head, every attempt should be made to reduce the head by—first, manipulations, and second, operative means. The head should never be removed only in exceptional cases. The results of excision of the head are uniformly poor and often disastrous. This statement holds good both for military and civil surgery. In a few cases the dislocated head can be left *in situ* and a good functional result obtained.

Dr. James N. Worcester spoke of the extent of the disability in simple fractures of the humerus which was out of proportion, often, to the anatomical difficulty; and when the latter was added the problem was worse. The thing to do was to bring the complicated cases into the position of a simple fracture by operation or otherwise. A marked feature was the pain of these fractures which made difficult the attempt to get return of function. If abduction and rotation were maintained from the start, this pain was absent. The speaker believed that impaction of the head of the humerus occurred after the original fracture had taken place and this explained the difficulty of regaining external rotation. Resection of the head should be avoided in every fracture of the upper end of the humerus at all costs.

Dr. Royal Whitman said that he had been pleased to learn from the discussion of the practical acceptance of abduction as the position of election for fractures with displacement, because many years ago he had called attention to the analogy of the hip and shoulder joints from the therapeutic standpoint. It was evident that the practically complete restoration of function in the cases presented, treated by immediate reduction and fixation, as well as in those treated by traction in bed, in spite of the fact that the alignment was not always satisfactory, was to be explained by the abducted attitude which prevented the restriction of movement that so often persisted when the fracture had been treated in the ordinary manner.

In the Annals of Surgery for May, 1908, he had described the abduction treatment by means of the shoulder spica and in particular a method of reducing and fixing epiphyseal fractures with the typical displacement of the shaft forward and upward, for which at that time there was no effective remedy, and which applied to similar fractures in older subjects. Manual traction was made upon the arm directly upward, thus rotating the scapula and bringing the axilla into lateral relief, so that by leverage of the shaft on the acromion and direct manipulation of the head, the fragment might be apposed. The arm was then fixed in this upright attitude with the forearm flexed over the head, and as the glenoid surface of the joint was in this attitude almost horizontal the force of gravity acting on the shaft apposed to the underlying head assured security.

He preferred to treat patients whenever practicable by the immediate reduction of the deformity and fixation rather than to divide the responsibility with assistants, which was one of the inevitable drawbacks of the traction treatment.

Dr. John F. Connors said that he thought his results from the use of the Thomas splint in these cases during the past two years led him to believe that these cases did very well. He attributed it to the fact that they became ambulatory cases sooner than the cases treated by the method of Doctor Santee. He agreed with Doctor Santee in regard to the so-called impacted fracture around the neck of the humerus and that in a great number of these cases that too much time was devoted in attempting to obtain a too good anatomical result, because if there is one class of fractures that needs motion

it is this class and the sooner the motion is begun the better will be the ultimate result. In reference to the operation for resection of the head of the humerus in these fractures our results have been much as described by Doctor Santee, and he believes that the operation was rarely indicated, for however poor the anatomical result in these cases, they seem to do better than the cases in which the head had been removed.